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Monterey, California



THESIS

**AN ANALYTICAL COMPARISON OF HUMAN FACTOR
MAINTENANCE RELATED PART FAILURES FOR
NAVAL RESERVE FLEET LOGISTICS SUPPORT WING**

by

Daniel L. Allen

December 1999

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PART FAILURES FOR NAVAL RESERVE FLEET LOGISTICS SUPPORT WING**

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ABSTRACT

Naval Aviation has experienced extensive change in recent years. Financial constraints, force reductions, and increasing operation tempo have impacted not only the material condition of Naval aircraft, but also the personnel who maintain them. The Naval Aviation Community has extensively studied the role of human factors in aviation mishaps. However, the need to study the impact of human factors in maintenance on part failures remains. As replacement parts for aircraft continue to rise in price, the need to mitigate the unnecessary failure/destruction of piece parts is and ever increasing priority. This study examines the relationship between part failures and human factors by comparing incident rates between VR Wing with the rest of Naval Aviation. Five hundred safety incident reports are analyzed; fiscal year totals are determined, and an incident per flying hour rate is computed. Regression results indicate an increasing trend in human factors related parts incidents; VR compares no different from the rest of Naval Aviation.

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LIST OF ACRONYMS

CFLSW	Commander, Fleet Logistics Support Wing
DOD	Department of Defense
DON	Department of Navy
FLSW	Fleet Logistics Support Wing
HFACS	Human Factors Analysis and Classification System
HFQMB	Human Factors Quality Management Board
HR	Hazard Report
MF-HZ	Material Failure Hazard Report
MH-HZ	Mishap Hazard Report
MIR	Mishap Investigation Report
NON-VR	Naval Aviation C-130, C-9, C-20 Aircraft other than VR Wing
NSC	Navy Safety Center
NSCDB	Navy Safety Center Database
PAT	Process Action Team
PT FAIL	Human Factor Part Failure
SIMS	Safety Information Management System
TPF	Total Parts-related Failures
SQN	Squadron/Organization Personnel
VR	Naval Designation for Fleet Logistics Support Squadrons

EXECUTIVE SUMMARY

Naval Aviation like all DOD activities has experienced extensive change in recent years. Financial constraints, force reductions, and increasing OPTEMPO have impacted not only the material condition of Naval aircraft, but also the personnel who maintain them. In recent years the Naval Aviation Community has extensively studied the role of human factors, especially air crew error, in safety incident rates. One such effort, the Human Factors Quality Management Board (HFQMB), was chartered to analyze and improve each of the processes, programs and systems that impact human performance in aviation, with the purpose of dramatically reducing the annual flight mishap rate.

In order to foster future gains the scope of the HFQMB was expanded to include maintenance. The concern is for the aging of Naval aircraft, the slowing of replacement aircraft acquisitions, vertical cuts in aircraft types, force reductions, and sustaining of current OPTEMPO. Out of the HFQMB a Process Action Team (PAT) was formed to look into the role of human factors pertaining to maintenance in safety incidences. This led to the development of the Human Factor Analysis and Classification System-Maintenance Extension (HFACS-ME) as a model to identify and classify human causal factors.

Commander, Fleet Logistics Support (VR) Wing (CFLSW) has taken a proactive stance on maintenance safety.

In support of this stance this study compares the parts-related safety incidences of the VR Wing to other similar Naval Aviation aircraft communities. As funding constraints tighten, the resources available to maintain VR Wing material readiness are impacted. Further straining financial resources, replacement parts for aircraft continue to rise in price. These constraints make it necessary to mitigate the unnecessary failure/destruction of piece parts in order to stretch every available dollar.

This study systematically examines the relationship between part failures and human factors in those failures. Of the 500 safety incident reports analyzed, 401 contained some form of parts-related failure. Those parts-related incidents are subdivided and categorized through data exploration process. Fiscal year tallies are generated, and a rate of incidents per flying hour is computed. The purpose of this data exploration is to obtain a quantitative baseline for regression analysis and hypothesis testing.

This research involves the analysis of Hazard, Mishap, and Material Failure Hazard Reports of C-130, C-9, and C-20 aircraft, maintained by the Naval Safety Center in the Safety Information Management System (SIMS) database. The

SIMS database is used because it links human factors to material failures. From this database 500 material related incidences ranging from fiscal year 1990 through 1999 are extracted and an exploratory data analysis is accomplished.

The results of this study provide Commander, Fleet Logistics Support Wing a baseline with which to raise maintainer awareness, both within and external to the VR Wing. The results show an increasing trend in parts-related failure. Eventhough the degree which human factors affect parts failures is not determined, one can infer from the analysis that human factors in maintenance are impacting readiness throughout the Naval Aviation community.

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I. INTRODUCTION

A. BACKGROUND

After the crash of an F14 fighter in Tennessee in 1996, which killed the aircrew members and civilians on the ground, an investigation of the crash pointed to human factors as the major cause (Nutwell & Sherman, 1997). This mishap, along with other similar human factors based mishaps, prompted immediate reaction by the Commander, Naval Air Force Pacific Fleet (COMNAVAIRPAC) to establish a Human Factors Quality Management Board (HFQMB). This HFQMB was chartered to analyze and improve each of the processes, programs and systems that impact human performance in aviation with the purpose of dramatically reducing the annual flight mishap rate.

The HFQMB used a three prong approach to get at human factor issues: Mishap Data Analysis, Benchmarking, and Climate Safety Assessment. Each provided a different perspective of the human factor problem. The insights gleaned by the HFQMB were briefed to the Navy's Air Board as well as the senior USMC leadership for consideration and support. This has led to several changes in Naval Aviation systems, programs, training, etc., which have notably served

to reduce Class A mishap rate (Schmidt, 1999 personal communication).

In order to foster future gains the scope of the HFQMB was expanded to include maintenance. The same three-prong approach was adapted that was used for aircrew; it was determined that human factors in maintenance is an important area to address (Schmidt, Schmorrow, & Hardee, 1998). Underscoring this concern are those related to the aging of Naval aircraft, the slowing of replacement aircraft acquisitions, vertical cuts in aircraft types, and the sustaining of current operation tempo. The Commander, Naval Air Systems Command addressed his concerns to the general Naval Aviation community and emphasized the importance of effective and preventive maintenance as they relate to aviation safety (Lockhardt, 1997). His belief was that through an aggressive and proactive maintenance program, valuable air assets could be preserved.

The Commander, Fleet Logistics Support Wing (CFLSW), in order to take a proactive stance on maintenance safety, enlisted the help of the School of Aviation Safety at the Naval Postgraduate School, Monterey CA, to examine human factors in maintenance issues in his organization. This partnership resulted in two theses, Teeters (1999) and Goodrum (1999). Teeters, building on a previous effort by

Schmorrow (1998), analyzed and modeled all maintenance related mishaps in the Fleet Logistics Support (VR) Wing community using the Human Factors Analysis and Classification System-Maintenance Extension (HFACS-ME). He determined which error forms were most prevalent and developed a methodology for forecasting the relational benefit of intervention strategies. Goodrum, expanding an earlier effort by Baker (1998), employed a Maintenance Climate Assessment survey to assess the perception of safety within the same VR Wing squadrons that had experienced the mishaps analyzed by Teeters. Finally, Sciretta (1999) in an unpublished letter report analyzed the Naval Safety Center's Maintenance Survey findings of the last two years for 13 of the 14 squadrons in the VR Wing. He identified the more common maintenance program discrepancies that were prevalent throughout the wing.

To complete the missing component of the previous human factor research this thesis compares parts-related safety incidences of VR Wing aircraft with those of other similar Naval Aviation communities, (referred to throughout this theses as "Non-VR" i.e., other Navy and Marine Corps C-130, C-9, and C-20 aircraft). From the Naval Safety Center (NSC) Safety Information Management System (SIMS) database, elements of Hazard, Mishap, and Material Failure Reports,

that were "parts related" for all VR Wing type aircraft (C-130, C-9, and C-20) were collected for analysis. The incident report information was classified by the degree human factors contributed to a part failure and whether the human factors were maintenance-related. Then, the HFACS-ME was used as a template to determine if the incident occurred as a result of Squadron or Non-Squadron maintenance practices. This study compares the findings to the Non-VR Naval Aviation community.

B. PROBLEM STATEMENT

Recent Department of Defense (DOD) financial constraints have impacted the VR Community. The decrease in funding required to maintain VR Wing material readiness has also had an impact. As replacement parts for aircraft continue to rise in price, the need to mitigate the unnecessary failure/destruction of piece parts becomes an ever increasing priority. The present study addresses the following questions:

1. Is there a difference in the rate of parts-related safety incidences between VR and Non-VR?
 - Is there a trend in VR or Non-VR?
 - Is there a difference in human factor (HF) parts-related safety incidences between VR and Non-VR; and is there a trend in VR or Non-VR?

- Is there a difference pertaining to human factor in maintenance (HF-ME) parts-related safety incidences between VR and Non-VR; and is there a trend in VR or Non-VR?

2. Does human factors in the VR community contribute to a higher incidence of part failures than the rest of the C-130, C-9, and C-20 community (Non-VR)?

- Is there a trend in human factors causing part failures in VR or Non-VR?

3. Is there a difference between Squadron (organizational level) and Non-Squadron (Depot, facilities, NAVAIR) human-factor in maintenance (HF-ME) parts related safety incidences for VR and Non-VR?

- Is there a trend in Squadron human-factor in maintenance causing part failures in VR or Non-VR? Non-Squadron?

4. Does Squadron human factors in the VR community contribute to a higher incidence of part failures than the rest of the C-130, C-9, and C-20 community (Non-VR)? Non-Squadron?

- Is there a trend in Squadron human factors causing part failures in VR or Non-VR? Non-Squadron?

C. OBJECTIVE

The purpose of this research is to determine if there is a difference in the rate of parts related safety incidences between VR and Non-VR aircraft communities. By utilizing part failure safety incidences reported in VR community aircraft mishap, hazard, and material failure hazard reports, a determination can be made suggesting if the VR Wing is experiencing undue parts failures as a result of human factor actions. The association between material

failures, human factors, and human factors in maintenance actions is examined to achieve a better understanding of VR Wing human factor involvement in parts failures as compared to the rest of Naval Aviation (Non-VR).

D. SCOPE AND LIMITATIONS

This study examines the relationship between human factor maintenance-related errors and their impact on part failures for the VR Wing. Each of the three reports (i.e. Mishap, HAZREP, and Material Failure), contained in NSC's SIMS, are analyzed and classified based on the HFACS-ME. Once classified, those maintenance-related incidences requiring repair parts are further examined to determine if Human Factors contributed to the cause of the failure. The results achieved from the analysis of the NSC-derived database are statistically compared (VR vs. Non-VR) to determine if the VR community differs from similar Naval Aviation communities and if a trend exists indicating a rise or decline in incident rates.

In a subsequent analysis, these results are further broken down into Squadron and Non-Squadron related material failures. Squadron related failures are those actions performed by Squadron personnel (organizational level); Non-Squadron related failures are those actions, resulting in parts failures, performed by other than squadron personnel

(i.e., depot, AIMD, facilities, etc.). This comparison provides the necessary validation to determine the extent human factors affect repair part failures and ultimately FSLW material and readiness posture.

Limitations inherent in the databases available include narrative data, absence of stock/part numbers, unreported incidences, cannibalizations, unrecorded maintenance, mislabeled or unidentified (bogus) parts, and possible duplication of reported incidences. SIMS Database reports from FY90 - FY99 are used in this study.

E. ORGANIZATION OF THE THESIS

Chapter II, Literature Review, describes initiatives and analyses in this area of research, NSC reports and database utilized, and issues related to Human Factors and material requirements.

Chapter III describes the methodology utilized in this thesis, including data exploration, classification, data analysis, linear regression, and hypothesis test procedures.

Chapter IV contains the results of the data classification, analysis, and hypothesis test.

Chapter V summarizes the conclusions and recommendations.

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II. LITERATURE REVIEW

A. BACKGROUND

1. Naval Fleet Logistics Support Wing

The Naval Fleet Logistics Support (VR) Wing was founded in 1974 to provide rapid response, flexible and contingency air logistic support to U. S. Maritime Forces, anywhere and anytime. It is composed of 14 Reserve Force Squadrons consisting of 4,500 personnel and 51 aircraft. Three major aircraft types make up the VR Wing. The current types of aircraft are the C-9B/DC-9, the C130T, and the C-20G/D with 27, 18, and 6 each of the respective types in the VR Wing's inventory. Within each aircraft type are configuration and life cycle variances, which may differentiate one aircraft from another within each type. These differences are due to modifications, field changes, or phased component replacements. Additionally, aircraft are at varying ages or differing stages in their operational life-cycles. Aircraft require different levels of maintenance depending on the age and accumulated operating hours. Adding greater diversity to the VR Wing inventory is the pending arrival of the C-17 aircraft, which will be phased-in to support the growing worldwide medium and heavy lift requirements (Peniston, 1998).

The logistics support that the VR Wing provides ranges from Inter-theater (Strategic) to Intra-theater (Operational) to Carrier Onboard Deliver (COD) (Tactical). In this environment the VR aircraft have compiled over 60,000 flights hours a year, representing 53 percent of the Naval Reserve Force total program and a \$1.7 billion capital investment. The VR Wing continues to exceed performance expectations in providing Global Logistics despite the increased operation tempo and the fact that the age of the VR aircraft ranges from 18 to 31 years. The ability to respond rapidly to contingency operations has ensured Fleet mobility and sustainability, while enabling Naval Forces to operate unencumbered through Maritime Air Logistics (NARA, 1999).

2. Human Factors Quality Management Board

The Human Factors Quality Management Board (HFQMB) was established to analyze human factor involvement in past Naval Aviation mishaps and in present Naval Aviation operations. In particular, it investigated Human Factor issues affecting tactical aircraft aircrew operations. Its approach (Figure 1), referred to as the "three-prong approach", uses information acquired from three areas, i.e., established practices benchmarking, mishap data analysis, and climate safety assessment. Its goal was to find ways to

improve readiness and mission success through controlling safety related hazards (Nutwell & Sherman, 1997).

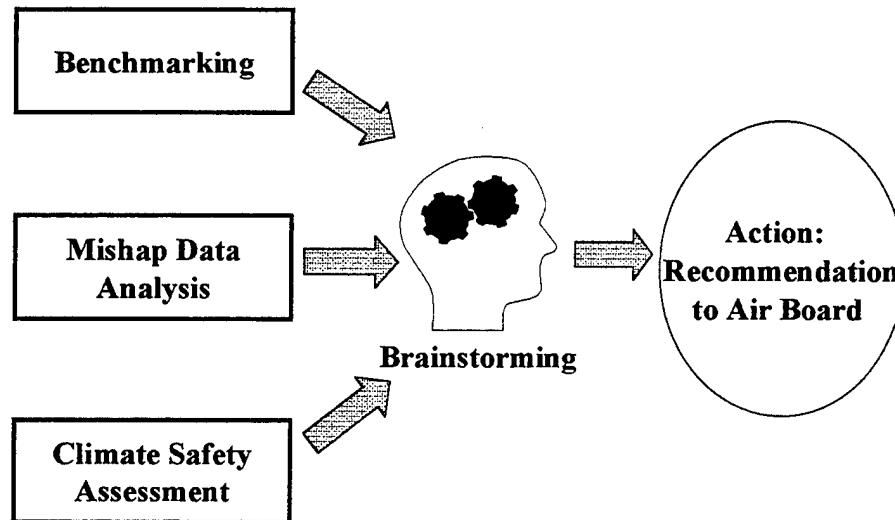


Figure 1. HFQMB Methodology.
From "AIRPAC Brief," by CDR J. Schmidt, March 1998

The HFQMB efforts yielded significant recommendations and results. It contributed to the Navy's safest year in Fiscal Year 1997. It directly contributed to the Marine Corps's safest year in Fiscal Year 1998 and the entire Naval Aviation community's safest year in Fiscal Year 1999. In light of the HFQMB's successful strategy of potentially reducing the number of mishaps attributed to aircrew operations error, the HFQMB broadened its focus to encompass

maintenance operations using the same three-prong approach (Schmidt, 1998/99 personal communication).

The HFQMB formed a new Process Action Team (PAT) which was tasked to assess human factors in maintenance and flight line operations using the three-prong approach since approximately one out of every five major mishaps involved maintenance error. Further, maintenance errors were even more prevalent in mishaps of lesser severity (Schmidt, Schmorrow, & Hardee, 1998).

3. Material Requirements

In a program, as demand for a part increases, its associated inventory model will respond by adding more safety level. This condition puts a stress on the organization's budget because inventory used to meet that demand will need to be acquired, in addition to the increased safety level. If maintenance-related human factors are a significant cause of this increase in demand, then identifying and reducing the causal factors will reduce the stress on the budget, which has the added feature of improving readiness.

The Naval Safety Center Data Base (NSCDB) SIMS, is the only resource which links human factor maintenance-related errors to material failures/part failures. A thorough comparison of FLSW parts related failures using the NSCDB

with similar Navy parts related failures will indicate the impact human factors have on the VR Wing, whether a significant difference between the two communities (VR and Non-VR) exists, and if the incident rate is changing. These results infer the degree to which human factors affect the VR Wing's material readiness and inventory requirements.

B. NAVAL AVIATION SAFETY PROGRAM

The Assistant Chief of Naval Operations (ACNO) Air Warfare has oversight responsibility for the Naval Aviation Safety Program. It includes all activities that may detect, contain, or eliminate hazards in Naval Aviation. It includes military and civilian personnel. It is based on the doctrine of necessitarianism and the belief that elimination of causal factors will inevitably reduce hazardous events [Department of the Navy (DON), 1991]. Based on this doctrine, it is through preventive measures that hazards can be eliminated thus preserving life and equipment (DON, 1991).

The Naval Aviation Safety Program was established to preserve human and material resources. It is monitored and tracked by the Naval Safety Center (NSC) (DON, 1991). NSC manages and retrieves aviation safety data which includes Mishap Investigation, Hazard, and Material Failure Hazard Reports.

1. Database

a) *Mishap Investigation Reports*

A mishap is defined as an unplanned event or series of events directly involving naval aircraft, which results in \$10,000 or greater cumulative damage to naval aircraft or personnel injury. The Mishap Investigation Report (MIR) is intended to report those hazards which are the cause of the reported mishap, damage and/or injury occurring during the mishap (DON, 1991). MIRs provide interested commands with notice of a mishap, preliminary information about the mishap, and mishap investigation progress.

b) *Hazard Reports*

A hazard is defined as a potential cause of damage or injury. As described in section (B) above, the Naval Aviation Safety program operates on the belief that elimination of causal factors will eliminate hazards. Therefore, the Naval Aviation Safety Program is designed to identify and eliminate hazards before they result in a mishap. The Hazard Report is intended to eliminate hazards via three methods; 1) report a hazard and remedial action taken, allowing others to identify the hazard and take necessary action to eliminate it, 2) report the hazard and

recommend corrective action to other organizations to eliminate the hazard, 3) report the hazard in order for another organization to determine corrective action to eliminate the hazard. An HR is submitted whenever a hazard (potential cause of damage or injury) is identified/detected (DON, 1991). The HR is used for hazard elimination information, while the MIR is used once a hazard results in a mishap. (DON, 1991).

c) Material Failure Hazard Reports

The Material Failure Hazard Report (MF-HR) is a subset of the HR data within SIMS. MF-HRs are identifiable as those hazard reports in which a material failure occurred or resulted from the incident/hazard. Submission requirements and purpose parallel that of the HR.

C. THE HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM-MAINTENANCE EXTENSION

Originally implemented to assist in the identification and classification of aircrew mishaps (Shappel & Wiegmann, 1997), the Human Factors Analysis and Classification System (HFACS) was adapted by Schmidt, Schmorow, and Hardee (1998) as a tool to analyze maintenance related human conditions. The adapted model is illustrated in Table 1.

Table 1. HFACS Maintenance Extension Categories

First Order	Second Order	Third Order
Supervisory Conditions	Unforeseen	Hazardous Operations Inadequate Documentation Inadequate Design
	Squadron	Inadequate Supervision Inappropriate Operations Failed to Correct Problem Supervisory Violation
Maintainer Conditions	Medical	Mental State Physical State Physical/Mental Limitation
	Crew Coordination	Communication Assertiveness Adaptability/Flexibility
	Readiness	Preparation/Training Qualification/Certification Violation
Working Conditions	Environment	Lighting/Light Exposure/Weather Environmental Hazards
	Equipment	Damaged Unavailable Dated/Uncertified
	Workspace	Confining Obstructed Inaccessible
Maintainer Acts	Error	Attention Memory Rule/Knowledge Skill
	Violation	Routine Infraction Exceptional

HFACS-Maintenance Extension (ME), consists of a hierarchy of maintenance related orders which are broken down into three levels or orders. Simply defined as first, second, and third order conditions, they serve to identify

causal factors within the HFACS-ME hierarchy. Table 1 summarizes the HFACS-ME hierarchical structure from the broad to micro category.

The first order consists of four broad human error categories. The first three, Supervisory Conditions, Working Conditions, and Maintainer Conditions represent latent conditions that may influence or impact a maintainer's performance, and lead to an active failure or ultimately, a mishap. The fourth first order category is Maintainer Acts. This final category includes active failures in which the maintainer's action directly contributes to the maintenance error.

D. PART FAILURE ANALYSIS

As is the case with most systematic analyses, many factors remain hidden in the details, never to surface until a tragedy or impromptu investigation discovers the anomaly. This section provides a detailed description of the studies, effort, and ongoing initiatives in the aviation arena. However, these initiatives do not include an analysis of part failures from a readiness perspective. This study examines the degree to which parts are failing as the result of maintenance actions.

If human factors are significantly affecting the expected life of repair parts, then it can be inferred that

human factors are degrading the readiness of the VR wing and/or naval aviation as a whole. Comparing the rate of occurrence of human factor parts related incidents between VR and Non-VR is a first-step in identifying causal factors. This study determines statistically the correlation between human factors and parts failures. Further, it proves statistically whether the VR community is experiencing a greater human factor parts impact than Non-VR communities using similar aircraft types.

E. SUMMARY

The evolution of the HFQMB and the maintenance PAT development have had a significant impact on the Naval Aviation Safety Program. This heightened awareness has influenced the VR Wing to institutionalize a proactive environment for the reduction of mishaps and elimination of hazards related to maintenance. The high OPTEMPO, when combined with dwindling financial resources and aging aircraft, has prompted the Commander of the VR Wing to request assistance from the Naval Postgraduate School's School of Aviation Safety. His belief is that an active analysis of maintenance practices and procedures will help eliminate causal factors, and in particular, those causal factors which are related to human factor conditions.

This study utilizes the HFACS-ME taxonomy to analyze the maintenance related mishap, hazard, and material failure hazard reports to evaluate if VR is causing substantial material failures due to Human Factors, and then to determine if these failure rates are equivalent Navy-wide. Derived from the HFACS, the maintenance extension is a proven tool to assist in the identification and classification of human error and the related causal factors.

This study focuses on incidences in which part failures occur in order to develop a baseline for the population. Once the population is established, it is tied to the first, second, and third order categories in the HFACS-ME, Table 1. By analyzing the trends relevant to these part failures one can statistically evaluate the degree Human Factors impacts the material readiness of the VR wing, and make a comparison between VR and Non-VR to determine if CFLSW has a significant human condition causing a degradation in the material readiness of the wing.

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III. METHODOLOGY

A. RESEARCH APPROACH

The intent of this study is to analyze data collected and maintained by the Naval Safety Center (NSC). The approach includes the extraction of material failure/deficiency related reports for the C-130, C-20, and C-9 aircraft from the Safety Information Management System (SIMS) database. This data consists of three types of reports, Material Failure Hazard (MF-HR), Mishap Hazard (MH-HR), and Mishap Investigation(MIR) Reports. These reports are formatted in accordance with OPNAV 3750.6 series. The format consists of a narrative section which describes the event and possible causal factors. A sample report is provided in Appendix A.

A review of 401 reports containing part failures is accomplished. These reports are segregated by VR and Non-VR. The reports are classified by causal factors using the Human Factors Analysis Classification System-Maintenance Extension (HFACS-ME) and evaluated using regression analysis and hypothesis testing techniques. The HFACS-ME is then expanded to determine which maintenance related human factor components are the result of squadron or non-squadron actions.

B. DATABASE

The SIMS database, maintained by NSC, is a compilation of occupational and operational reports (i.e., Personnel Injury Reports (PIR) and Mishap Investigation Reports (MIR)) received from Navy and Marine Corps activities. The database is populated through manual entry in ASCII format (Sciretta, 1999). It was queried for reports containing material failures on Navy and Marine Corps C-130, C-20, and C-9 aircraft communities. A total of 500 material related failure reports were obtained. The resulting reports included Material Failure Hazard Reports (MF-HR), Mishap Investigation Reports (MIR), and Mishap Hazard Reports (MH-HR) from FY90 - FY99. Each report contains similar fields of data (Appendix A). Data includes the event number, date, hazard type (i.e., general, flight related or ground mishap, and class), aircraft model, controlling custodian (i.e., Naval Reserve, MARFORPAC, COMNAVAIRLANT), event summary, and causal factors.

C. PROCEDURE

The resulting ASCII format output files from querying the SIMS database were saved in Microsoft Word format. Once in Word format each report is further formatted, extra spacing removed, text is "word-wrapped" and condensed through manual effort to facilitate the analysis. The

narratives and causal factors are studied to determine if a part failure occurred, and a new subset of data is created. This data set is referred in this thesis as "Total Part Failures" (TPF). It includes those reports in which a part caused a reported safety incident or failed as a result of a reported safety incident. This TPF data set is further analyzed to determine if the part failure is related to the following. (Figure 2 describes the data set relationship and the flow of the analysis):

- Human Factors
- Human Factors related to a maintenance action
- Maintenance action directly contributed to the part failure
- Caused further damage
- Squadron or Non-Squadron

As described in Figure 2, the initial query of the NSC SIMS database resulted in 500 MIR, MF-HR, and MH-HR Reports for C-130, C-9, and C-20 aircraft. Once formatted, the narratives are analyzed to determine which events contain part failures. This sub-classification produced 401 report narratives (80%) indicating some form of part failure (i.e., wear-out, breakage, shutdown). Using the 401 part failure

occurrences, the next step separates those reports where human factors are involved.

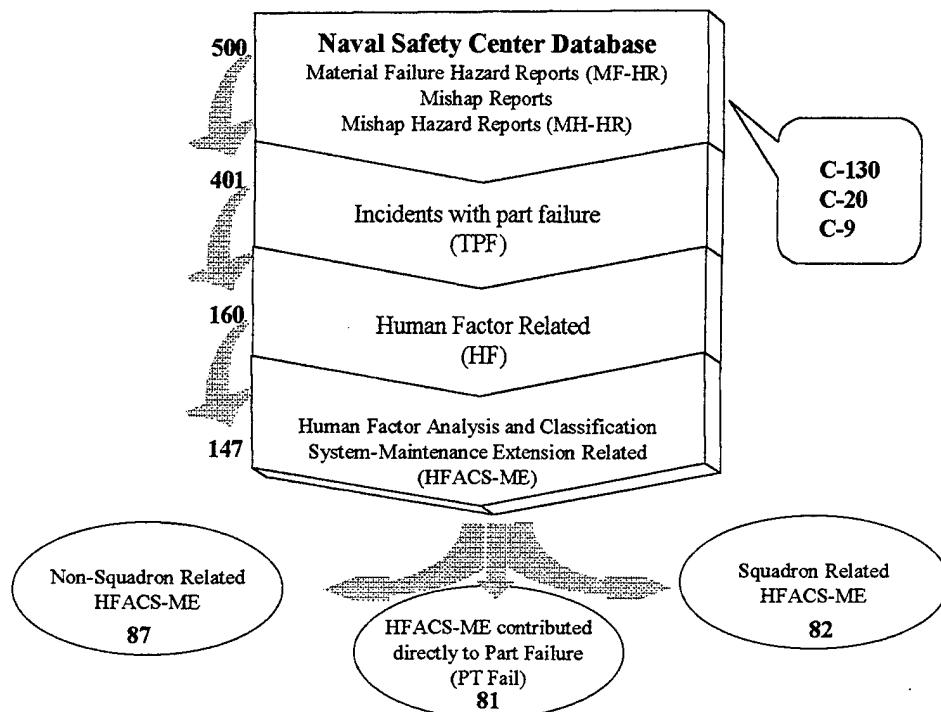


Figure 2. Hierarchical Data Flow

Of the 401 reports indicating a part failure, 160 indicate some form of human factor involvement (40%). These 160 are subjected to the HFACS-ME extension to determine which human factor events are maintenance related. 147 of the 160 human factor report occurrences (92%) contain some form of maintenance action, latent and/or active.

A running tally of each subset is maintained as the SIMS data set is subjected to further analysis. The next

step determines which, if any, of the 147 HFACS-ME related part failures were caused directly or indirectly through maintenance error, or that the maintenance error contributed to the part failure. Of the 500 reports analyzed, 87 indicated a maintenance related human factor event contributed directly or indirectly to the part(s) failure (17%). The results of each step in the analysis are then subdivided into two groups. The first group is the VR Wing interest; the second is Non-VR Naval Aviation for the aircraft types C-130, C-9, and C-20.

A subsequent data analysis is conducted using the HFACS-ME subset (147 records). The HFACS-ME model is applied to this data set to determine which records indicate the part failure was the cause of an action on behalf of the squadron and/or of another facility, such as a depot, general facilities personnel, Naval Air Systems Command, etc. It is noted that multiple human factors may be involved (Appendix A), and an event may include both a squadron error as well as a non-squadron error. In this case, an event is tallied twice, one a squadron error, one a non-squadron error.

The same analysis is then applied to the HFACS-ME part failure subset (81 reports) to gain some insight into whether squadron or non-squadron activities are contributing

to the failure of parts either directly or indirectly, and to what extent these failures are occurring. The resulting subset includes 51 squadron related (63%) and 43 non-squadron related part failures (53%) resulting from human factors in maintenance.

This information is entered into a Microsoft Access table, queries are run, and tallies are generated for each category/subcategory (i.e. HF, HFACS-ME, HFACS-ME part failure, Squadron, Non-Squadron). This tally information is entered into a Microsoft Excel workbook (Flying Hour Worksheet) described in Appendix B. Annual flying hour data provided by NSC is also entered into the worksheet. Yearly tallies are accumulated, and events per flying hour rates are calculated (Appendix B).

The event rate is derived by dividing the fiscal year tallies collected in the data analysis by the number of flying hours reported for each aircraft type, and command. For example, the total part failures for a given fiscal year are divided by the flying hours for that same fiscal year (i.e. tally/flying hours = event rate) for VR and then Non-VR. This step is repeated for each subset of data and for each aircraft type.

The resulting ratio forms the basis for the comparison. Appendix B contains the tally (count), flying hours, and the

resulting ratios. A graphical representation of the ratios are include in Appendix C. This appendix provides a visual representation of the scope of differing ratios for each subset of data and/or aircraft type.

The ratio data are then input into another Excel work sheet. Using Excel statistical functions a regression analysis is run (Levine, Berenson, & Stephan, 1998). The regression analysis is chosen as a means of examining these ratios and their relationship. By using a linear regression one can determine if a correlation exists between VR and Non-VR, and the strength of the association between the fiscal year and the rate of parts-related incidents (Levine, et al, 1998).

The resulting regression lines are then subjected to two hypothesis tests using the two-tailed t-test with a significance level of alpha = .1 (Levine, et al, 1998). In the first test, the two-tailed t-test is utilized as a hypothesis testing tool to determine if the slopes of the VR Wing regression line (β_1) differs from slope of the Non-VR regression line (γ_1). The observed t-statistic is computed as,

$$t = \frac{\hat{\beta}_1 - \hat{\gamma}_1}{\hat{\sigma} \sqrt{\frac{1}{\sum(X_{1,i} - \bar{X}_1)^2} + \frac{1}{\sum(X_{2,i} - \bar{X}_2)^2}}}$$

If the hypothesis test ($\beta_1 = \gamma_1$) cannot be rejected then the slopes of these lines are statistically the same. If the slopes are the same then one infers that the VR rate of parts-related incidents is not any different than the rest of Naval Aviation.

In the second test, the regression lines are subjected to an independent hypothesis test ($\beta_1 = 0$) to determine if a trend exists between the tally/flying hour ratio and the fiscal year. If the hypothesis is rejected then one infers that there is a trend. The direction of the trend is determined by the sign of the slope (i.e. increasing trend for positive slope, decreasing trend for negative slope). Excel automatically computes the observed t-statistic for this test.

D. DATA ANALYSIS

1. Data Tabulation VR vs Non-VR

Each report provided by NSC includes varying levels of detail. As each event is analyzed a tally is maintained for each general category. The tally results are subjective in nature as the report narratives do not necessarily state what causal factors are inherent in each incident. The tallies are categorized base on the author's assessment of the available information.

The following categories are described (Figure 2 refers):

- 1) reports in which a part failure occurred (TPF);
- 2) reports that had a part failure in which the narrative includes some form of human factor involvement;
- 3) the human factor included an activity, latent or active, addressed in the HFACS-ME model (Table 1 refers); and
- 4) the activity resulted in the part failure.

Each event is tallied according to the general category for VR and Non-VR aircraft and aircraft type.

2. Data Tabulation Squadron vs Non-Squadron

Subsequent to the tabulation conducted above, the data tally relating to the general category HFACS-ME is further subdivided. As an extension to the HFACS-ME matrix, the same criteria is applied as if the HFACS-ME act were the result of squadron (SQN) actions or non-squadron (Non-SQN) actions. Squadron causal factors are the result of squadron or organizational (O-level) personnel; non-squadron actions are the result of personnel not assigned to the squadron.

Examples of non-squadron activities include depot

maintenance facilities, non-squadron airport facilities personnel (i.e., fire/rescue and ground personnel).

3. Statistical Analysis

The number of parts related failures for each general category and aircraft type (C-130, C-9, C-20) are accumulated during the data tabulation phase and divided by the flying hours for the fiscal year in which the event occurred. The resulting tally-per-flying hour rates form the baseline for the statistical analysis. Each set of yearly rates describe a unique linear regression line which is compared against its counterpart (VR Vs Non-VR), and plotted (Appendix C). Microsoft Excel is used to process the regression analysis. Excel does this automatically with Tools/Data Analysis/Regression function.

For the purpose of this study the fiscal year is the independent (x) variable and the tally/flying hour ratio is the dependent (y) variable. Results are listed in Appendix D. The results of the regression analysis are then subjected to a hypothesis test to compare the slope of the regression line for VR against the slope of the regression line of Non-VR. This hypothesis test is conducted for each general category/subcategory containing adequate data points to warrant testing. The null hypothesis being tested is whether the VR slope (β_1) equals the slope of the Non-VR

(γ_1) regression line ($\beta_1 = \gamma_1$). A t-statistic test for the null hypothesis is applied to each general category and to the C-130 aircraft type as a subcategory.

Each regression line is further analyzed to determine if a trend exists. The null hypothesis suggests that if the slope of the regression line equals zero ($\beta_1 = 0$), then there is no trend inherent in the data. A two-tailed t-test is conducted with $\alpha = 0.1$. If the p-value resulting from the regression analysis is less than α the null hypothesis is rejected suggesting an upward or downward trend does exist.

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IV. RESULTS

A. INTRODUCTION

Using simple linear regression as a tool to analyze data leads to many ethical considerations. Issues include data contamination, human error in data interpretation, inappropriate level of significance selection, test selection (one or two tailed), and data cleansing (Levine, et al, 1998). Throughout the data exploration phase every precaution is taken to attain the most accurate test results possible.

B. HYPOTHESIS TESTING VR COMMUNITY

The resulting p-values of the hypothesis test $\beta_1 = 0$ for the VR community are displayed in Table 2. The column headings represent the HFACS classification while the row headings represent the total community and the subset of type of aircraft. Given a level of significance of .1 the data suggests rejecting the null hypothesis for each of the "total classifications." Rejecting the null hypothesis indicates that there is a statistical relationship between the independent variable (fiscal year) and the dependent variable (parts-related incidents per flight hour). For VR as a whole this suggests that the parts-related incidents

per flight hour that are reported annually are increasing each year. It also indicates an increase in parts-related Human Factors incidents, and parts-related Human Factor Maintenance incidents. Most importantly, though, it indicates that there is an increasing trend in the rate of Human Factors causing material failure. In particular, this increase appears to be highly influenced from the VR C-9. It is worthy to note that the trend is based on 10 years of data. Fiscal year 1999 shows a significant drop in the parts-related incidents per flight hour. Although one data observation does not in itself signal a trend, in this case, due to the Navy's concerted effort to implement improved safety programs in the past two years, the significant decrease could be a signal of a downward trend.

Table 2. VR Community Hypothesis Test ($\beta_1=0$) p-values

	TPF	Human	HFACS-ME	PT Fail
Factors				
Total	.00016	.03355	.04182	.00949
C-130	.06386	.12203	.08517	.42561
C-9	.53018	.23424	.29773	.06535
C-20	.77672	.92369	.92369	N/A

Regression was not conducted in those areas where data did not exist and is represented by N/A in Tables 2 through 8.

C. HYPOTHESIS TESTING NON-VR COMMUNITY

The resulting p-values of the hypothesis test $\beta_1 = 0$ for the Non-VR communities are displayed in Table 3. Column headings are exactly the same as those for the VR community. Given a level of significance of .1 the data suggests rejecting the null hypothesis for each of the "Total" classifications and for each of the "C-130" classifications. There was not enough data to generate regression lines for the "C-9" and "C-20" classifications. Rejecting the null hypothesis indicates that there is a significant relationship between the fiscal year and the parts-related incidents per flight hours. Also, as in the VR community, the data suggests an increasing trend in Human Factors causing parts failures. It is noted that, as in the VR community, fiscal year 1999 rate of Human Factors causing material failures dropped from fiscal year 1998. Based on the navy's efforts in implementing better safety programs this "drop" could be a signal of a downward trend. It is also noted that the C-130 community is influencing the increasing trend.

Table 3. Non-VR Hypothesis Test ($\beta_1=0$) p-values

	TPF	Human	HFACS-ME	PT Fail
Factors				
Total	.00998	.03264	.03696	.00954
C-130	.04654	.06448	.07885	.06537
C-9	N/A	N/A	N/A	N/A
C-20	N/A	N/A	N/A	N/A

D. HYPOTHESIS TESTING SQUADRON RELATED HFACS-ME

The resulting p-values of the hypothesis test $\beta_1 = 0$ for the squadron related HFACS-ME are provided in Table 4. Given a level of significance of .1 the data suggests rejecting the null hypothesis for HFACS-ME for the VR community and HFACS-ME C-130 for the Non-VR communities.

Table 4. Squadron HFACS-ME Hypothesis Test ($\beta_1=0$) p-values

	VR	NON-VR
Total	.05587	.44159
C-130	.81390	.09768
C-9	.70052	N/A
C-20	N/A	N/A

Rejecting the null hypothesis suggests the slope of the regression line is not zero, which means a trend exists, in these two cases, increasing trend.

E. HYPOTHESIS TESTING NON-SQUADRON RELATED HFACS-ME

The resulting p-values of the hypothesis test $\beta_1 = 0$ for the Non-squadron related HFACS-ME are provided in Table 5. Given a level of significance of .1 the data suggests ejecting the null hypothesis for HFACS-ME for the VR and Non-VR communities.

Table 5. Non-Squadron HFACS-ME Hypothesis Test ($\beta_1=0$) p-values

	VR	NON-VR
Total	.03507	.03751
C-130	.70806	.99069
C-9	.65016	N/A
C-20	.86085	N/A

F. HYPOTHESIS TESTING SQUADRON AND NON-SQUADRON RELATED HFACS-ME PART FAILURES

The resulting p-values of the hypothesis test $\beta_1 = 0$ for the Squadron and Non-Squadron related HFACS-ME related part failures are provided in Table 6. As discussed in

Chapter III this data set consists of occurrences in which the human factors in maintenance caused, directly or indirectly, the part to fail. Given a level of significance of .1 the data suggests rejecting the null hypothesis for all but Squadron VR maintenance related part failures. This means that there appears to be no significant increase or decrease of Squadron human factors causing part failures in the VR community. The same cannot be statistically shown for Squadron human factors causing parts failures in the Non-VR community, nor can it be shown for Non-Squadron human factors causing parts failures within the Navy/Marine Corps combined logistics community. In other words, all non-squadron activities which maintain VR and Non-VR aircraft are showing an increased propensity to cause parts to fail. The same can be said for squadrons maintaining Non-VR aircraft.

Table 6. Squadron and Non-Squadron HFACS-ME Part Failure Hypothesis Test ($\beta_1=0$) p-values

	SQN	NON-SQN
VR	.25865	.00159
Non-VR	.02727	.08084

The VR squadron graph in Appendix C suggests this result may be skewed as fiscal years 92 through 94 data points remained constant with little to no variation. This is an anomaly when considering all the data analyzed in this research.

G. HYPOTHESIS TEST VR VS NON-VR

The results of the hypothesis test comparing VR regression line slope (β_1) against Non-VR (γ_1) regression line are contained in Tables 7 and 8. The test can only be conducted for those data sets where both VR and Non-VR regression analysis could be conducted.

Table 7. VR vs Non-VR Hypothesis Test ($\beta_1=\gamma_1$) t-statistic

	TPF	Human Factors	HFACS-ME	PT Fail
Total	.24409	-.58252	-.60293	-.86256
C-130	.97110	.22408	.34882	-.84114

Based on these results the null hypothesis ($\beta_1 = \gamma_1$) cannot be rejected for any category. The slopes of the corresponding regression lines are not statistically different and therefore indicate no difference in the failures per flight hour rates. Even though the rates are

increasing, it appears that VR is not behaving any differently than the rest of the Navy.

Table 8. Squadron and Non-Squadron VR vs Non-VR Hypothesis Test ($\beta_1=\gamma_1$) t-statistic

	SQN	Non-SQN	SQN	Non-SQN
	PT Fail		PT Fail	
Total	-.14101	-1.00433	-.93707	-.18079
C-130	-.83693	.27211	N/A	N/A

H. SUMMARY

The use of regression analysis is a valuable tool to draw conclusions about a given population. This study uses inferential statistics, including data collection, exploration, presentation, regression, and the analysis of the data through hypothesis testing. Limitations in the available data can affect the results.

Results from this analysis indicates increasing trends. However, are these trends the result of aging aircraft, increased OPTEMPO, or unqualified/trained personnel? Are the increasing trends the result of heighten awareness, and the belief within Naval Aviation that reporting these types of incidents/events will not damage one's career? Or, is

this the result of more safety reports being initiated fleet-wide in an effort to mitigate the loss or life or property? The questions posed are not resolved here, but are left with the Naval Aviation Safety Program to shed some light.

Another issue potentially affecting the data is that during this time period the Navy was experiencing Base Realignment and Closure (BRAC), which resulted in numerous activity consolidations and disestablishments. This fleet wide activity may have influenced incident reporting during the time period.

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V. CONCLUSIONS AND RECOMMENDATIONS

This study examines the relationship between part failures and human factors in maintenance involvement in those failures. Of the 500 safety incident reports analyzed, 401 contained some form of parts-related failure. Those parts-related incidents are subdivided in accordance with the data exploration process discussed in Chapter III. Fiscal year tallies are generated and divided by the total fiscal year flying hours to compute a rate of incidents per flying hour. The purpose of this data exploration was to obtain a quantitative baseline for regression analysis and comparison hypothesis testing.

The Naval Safety Center Safety Information Management System database is used because it links human factors to material failures. Consisting of narrative events, the data contained in this data base enables a subjective assessment of the role of human factors in the part failures. The foundation of this study is that if the slopes of the VR and Non-VR regression lines are equal than there is no difference between the VR community and the rest of similar Naval Aviation communities regardless of trend. This hypothesis is tested at the 10% significance level or 90% confidence level.

The results are presented in Chapter IV. The questions asked in this study are designed to solicit perceptions about the potential impact human factors have on part failures and ultimately material readiness. Data results form the basis for the following conclusions and recommendations regarding trend analysis, the impact of human factors on parts requirements, and potential differences between VR and Naval Aviation. Also discussed are additional recommendations for reporting material safety incidents and follow-on research.

A. VR AND NON-VR PARTS RELATED SAFETY INCIDENTS

1. Conclusion

As shown in Chapter IV, statistically there is no difference in the rate of parts related, human factor, or human factor in maintenance safety incidences between VR and Non-VR communities. However, the results of this study do indicate an increasing trend of human factor involvement in parts failures for the VR community as well as Non-VR activities. One can infer from the analysis that human factors in maintenance may be impacting readiness in both VR and Non-VR squadrons. Although there may be many causes for the existence of an increasing trend, the presence of a positive trend suggests Mishap, Hazard, and Material Failure Reports support the conclusion that human factors, and

particularly HFACS-ME, are present in the aviation maintenance system.

2. Recommendation

The primary research question of this study was to determine if VR was statistically different in terms of parts related incidents and human factor relationships than Non-VR. Quantitative findings support the conclusion that the VR Wing is no better or worse than the rest of the Naval Aviation logistics community. However considering the growing trend, continued attention must be placed in this area in order to reduce human factor influences.

B. HUMAN FACTORS AND PARTS FAILURES IN THE VR AND NON-VR COMMUNITIES

1. Conclusion

Again, as shown in Chapter IV, statistically there is no difference between the human factor induced part failure rates for the VR community vs Non-VR communities. However, the results of this study do indicate an increasing trend in the human factors induced part failure rates for the VR and Non-VR communities. One can infer from the analysis that although there is no statistical difference between VR and Non-VR, human factors in maintenance are impacting parts requirements and that parts failures as a result of human causal factors is on the rise.

2. Recommendation

A primary objective of this research question is to determine if the Commander Fleet Logistics Support Wing should concentrate his limited resources in an effort to mitigate parts usage resulting from human error. Quantitative findings support the conclusion that the VR Wing is no different in this area than the rest of the Naval Aviation logistics community. However, a growing trend does exist and continued efforts are essential in order to eliminate unnecessary parts requirements and eliminate the wasting of valuable financial resources on piece parts damaged as a result of human error.

C. SQUADRON AND NON-SQUADRON INFLUENCES ON VR AND NON-VR PARTS AND MAINTENANCE RELATED SAFETY INCIDENTS

1. Conclusion

Another purpose of this research question is to determine if squadron (organizational level) maintenance errors have a different impact on VR and Non-VR communities; and to determine if non-squadron (i.e. depot, facilities, SYSCOM) maintenance error is different. Again, the quantitative results in Chapter IV suggest that there is no difference between squadron or non-squadron related maintenance errors for the VR or Non-VR communities. In fact the occurrences of squadron and non-squadron incidents are

similar. The results in Chapter IV also show a growing trend in both squadron and non-squadron human factor in maintenance safety incidents. This growing trend is also present when looking at the individual VR or Non-VR results.

2. Recommendation

The results in Chapter IV demonstrate that VR is not statistically different from Non-VR for squadron related maintenance errors or for non-squadron maintenance errors. However, a growing trend is present which suggests that both organizational maintainers and other maintainers (depots, airfield personnel) need to step-up their efforts and ensure compliance with maintenance standards and operating procedures. An improved effort by non-squadron personnel may help mitigate those errors caused by inadequate inspections prior to and following overhauls, and eliminate unnecessary incidents resulting from facilities personnel being unfamiliar with the aircraft they are servicing or the squadron's standard operating procedures. Squadron personnel must continue to eliminate hazards, and ensure proper procedures exist and are followed during maintenance procedures.

D. SQUADRON AND NON-SQUADRON HUMAN FACTORS AND PARTS FAILURES IN THE VR AND NON-VR COMMUNITIES

1. Conclusion

As shown in Chapter IV, statistically there is no difference between the human factor induced part failure rate for the VR community and non-VR communities based on squadron or non-squadron influences. As with previous findings, the results of this study indicate an increasing trend in the human factors induced part failure rates for VR non-squadron activities and at both the squadron and non-squadron level for the Non-VR communities. Human factors in maintenance activities are impacting parts requirements and that parts failures as a result of human causal factors is on the rise.

2. Recommendation

A growing trend is present in the data which suggests that both organizational maintainers and other maintainers (depots, airfield personnel) need to reduce the impact their actions have on parts, and the material readiness of Naval Aviation squadrons. The growing trend supports the idea that progress can be made to eliminate the unnecessary use of spare parts both at squadron and at non-squadron activities.

E. MISCELLANEOUS FINDINGS

1. Conclusion

The data utilized in this analysis (Material Failure, Mishap Investigation, and Hazard Reports) is in a format not conducive to an exploratory data analysis. The ASC II format enables a wide range of personnel to utilize the narratives, but categorical searches are not possible. The database is populated via manual entry by safety center personnel vice an automated method. This leads to key punch errors and omissions. Further, the database is a "stand-alone" system which does not interface with existing data repositories or financial information.

2. Recommendation

The Naval Safety Center plays a critical role in the mitigation of hazards throughout the fleet. Its purpose is to protect our sailors, marines, and civilian personnel and property of the U. S. Navy and Marine Corps. The data fields maintained in these reports should be linked and contain additional information such as a national stock number or part number when dealing with material issues. Also a data base which is accessible and can interface with other data repositories, and network systems will make it easier to conduct research and possibly identify additional areas of study or hazards hidden in the "weeds."

F. FOLLOW-ON RESEARCH

Follow on analysis is needed to examine the relationship between depot maintenance activities resulting from consolidations and outsourcing, and human factor incidences. Utilizing these same aircraft types, an analysis of depot maintenance activities may lead to activities requiring an organizational climate assessment. The heightened awareness brought about by such an assessment may help mitigate the maintenance related part failure occurrences and ultimately eliminate potential hazards.

APPENDIX A: SAMPLE NAVAL SAFETY CENTER HAZARD REPORT

EVENT DATA:

Event Serial: 00000 Date:
HAZARD - GENERAL

Responsible Aircraft Data:

Model: C009B Controlling Custodian: SAMPLE Ashore

AIRCRAFT DATA:

Model:

SUMMARY:

Event Summary:

ELECTRICAL SMOKE AND SPARKS IN COCKPIT DURING ACFT START.

DURING ROUTINE TRAINING, MAINTENANCE TECHNICIAN TURNED ON THE RIGHT APU BUS AND OBSERVED BLUE SPARKS AND SMOKE COMING FROM UNDER THE INSTRUMENT PANEL. AFTER SPARKS SEVERAL CIRCUIT BREAKERS POPPED BEFORE APU BUSES COULD BE SECURED. ALTHOUGH PROVIDED WITH A HAND-HELD RADIO FOR COMMUNICATIONS WITH MAINTENANCE CONTROL, THE BATTERIES WERE INOP. THE TECHNICIAN THEN SELECTED EMERGENCY POWER ON (ENERGIZING THREE ADDITIONAL BUSES) TO CALL MAINTENANCE CONTROL.

CAUSE FACTORS: (1) MAINTENANCE: (A) MAINT PERSONNEL: FAILED TO FOLLOW SAFETY PROCEDURES WHEN ALL ELECTRICAL POWER WAS NOT COMPLETELY SECURED. MAINTENANCE MAINTAINERS MUST BE REMINDED TO COMPLETE THEIR EMERGENCY PROCEDURES FIRST THEN WORRY ABOUT TELLING MAINTENANCE CONTROL. (2) MATERIAL: (A) CANNON PLUG WIRING: SHORTED/ARCED CAUSING BLUE SPARKS AND SMOKE AND BURNT BLACK CHARRED WIRES. AFTER ALL POWER WAS SECURED, MAINT DISCOVERED BURNT BLACK CHARRED WIRES ON THE BACK OF A CANNON PLUG NEAR THE COPILOT'S LEFT RUDDER PEDAL. CONCLUSIONS: BURNING WIRES CREATE TOXIC FUMES, THE POTENTIAL FOR ELECTROCUTION OF PERSONNEL AND COULD RESULT IN FIRES DAMAGING THE ACFT.

Figure A-1. Sample Naval Safety Center Hazard Report

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APPENDIX B: TALLY/FLYING HOUR WORKSHEETS

TOTAL PART FAILURES

<u>FISCAL YEAR</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>TOTAL</u>
PART FAILURES											
VR	12	14	11	15	20	30	29	25	30	32	218
Non-VR	14	20	15	13	15	16	17	26	28	19	183
TOTAL	26	34	26	28	35	46	46	51	58	49	399
FLYING HOURS											
VR	49633	45573	44888	51546	56209	59964	61296	60023	53587	53899	536618
Non-VR	62444	57049	47979	45773	43217	44016	44950	43727	40191	44134	473480
TOTAL	112077	102622	92867	97319	99426	103980	106246	103750	93778	98033	1010098

TOTAL PART FAILURES PER AIRCRAFT TYPE

<u>FISCAL YEAR</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>TOTAL</u>
PART FAILURES											
VR											
C-130	0	0	0	6	5	12	15	13	19	18	88
C-9	12	14	11	9	14	16	13	10	7	13	119
C-20	0	0	0	0	1	2	1	2	4	1	11
Non-VR											
C-130	14	20	15	10	15	16	14	22	26	19	171
C-9	0	0	0	3	0	0	0	0	1	0	4
C-20	0	0	0	0	0	0	3	4	1	0	8
FLYING HOURS											
VR											
C-130	22	396	2900	6426	10214	13199	13567	13891	13726	14723	89064
C-9	48174	44017	40527	43975	43710	41616	41232	38357	33135	34177	408920
C-20	1437	1160	1461	1145	2285	5149	6497	7775	6726	4999	38634
Non-VR											
C-130	58921	53641	45069	42673	40431	41008	41555	40345	37980	41311	442934
C-9	3504	3394	2898	3063	2730	2647	2545	2188	1909	2823	27701
C-20	19	14	12	37	56	361	850	1194	302	0	2845

RATIO

<u>FISCAL YEAR</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>TOTAL</u>
VR	0.00024177	0.000307	0.000245	0.000291	0.000356	0.0005	0.000473	0.000417	0.00056	0.000594	0.0004062
Non-VR	0.0002242	0.000351	0.000313	0.000284	0.000347	0.000364	0.000378	0.000595	0.000697	0.000431	0.0003865

RATIO PER AIRCRAFT TYPE

<u>FISCAL YEAR</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>TOTAL</u>
VR											
C-130	0	0	0	0.000934	0.00049	0.000909	0.001106	0.000936	0.001384	0.001223	0.0009881
C-9	0.0002491	0.000318	0.000271	0.000205	0.00032	0.000384	0.000315	0.000261	0.000211	0.00038	0.000291
C-20	0	0	0	0	0.000438	0.000388	0.000154	0.000257	0.000595	0.0002	0.0002847
Non-VR											
C-130	0.00023761	0.000373	0.000333	0.000234	0.000371	0.00039	0.000337	0.000545	0.000685	0.00046	0.0003861
C-9	0	0	0	0.000979	0	0	0	0	0.000524	0	0.0001444
C-20	0	0	0	0	0	0	0.003529	0.00335	0.003311	#DIV/0!	0.002812

Figure B-1. Total Part Failure Tally/Flying Hour Worksheet

TOTAL PART FAILURES, HF

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR	6	8	4	1	4	9	14	15	11	14	86
Non-VR	5	8	3	7	4	1	7	15	14	10	74
TOTAL	11	16	7	8	8	10	21	30	25	24	160

FLYING HOURS

VR	49633	45573	44888	51546	56209	59964	61296	60023	53587	53899	536618
Non-VR	62444	57049	47979	45773	43217	44016	44950	43727	40191	44134	473480
TOTAL	112077	102622	92867	97319	99426	103980	106246	103750	93778	98033	1010098

TOTAL PART FAILURES, HF PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR											
C-130	0	0	0	0	1	2	7	4	6	6	26
C-9	6	8	4	1	3	7	6	9	4	7	55
C-20	0	0	0	0	0	0	1	2	1	1	5

Non-VR

C-130	5	8	3	6	4	1	7	12	14	10	70
C-9	0	0	0	1	0	0	0	0	0	0	1
C-20	0	0	0	0	0	0	0	3	0	0	3

FLYING HOURS

VR											
C-130	22	396	2900	6426	10214	13199	13567	13891	13726	14723	89064
C-9	48174	44017	40527	43975	43710	41616	41232	38357	33135	34177	408920
C-20	1437	1160	1461	1145	2285	5149	6497	7775	6726	4999	38634

Non-VR

C-130	58921	53641	45069	42673	40431	41008	41555	40345	37980	41311	442934
C-9	3504	3394	2898	3063	2730	2647	2545	2188	1909	2823	27701
C-20	19	14	12	37	56	361	850	1194	302	0	2845

RATIO

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR	0.00012089	0.000176	8.91E-05	1.94E-05	7.12E-05	0.00015	0.000228	0.00025	0.000205	0.00026	0.00016
Non-VR	8.0072E-05	0.00014	6.25E-05	0.000153	9.26E-05	2.27E-05	0.000156	0.000343	0.000348	0.000227	0.000156

RATIO PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR											
C-130	0	0	0	0	9.79E-05	0.000152	0.000516	0.000288	0.000437	0.000408	0.000292
C-9	0.00012455	0.000182	9.87E-05	2.27E-05	6.86E-05	0.000168	0.000146	0.000235	0.000121	0.000205	0.000135
C-20	0	0	0	0	0	0	0.000154	0.000257	0.000149	0.0002	0.000129
Non-VR											
C-130	8.4859E-05	0.000149	6.66E-05	0.000141	9.89E-05	2.44E-05	0.000168	0.000297	0.000369	0.000242	0.000158
C-9	0	0	0	0.000326	0	0	0	0	0	0	3.61E-05
C-20	0	0	0	0	0	0	0	0.002513	0	#DIV/0!	0.001054

Figure B-2. TPF Human Factor Tally/Flying Hour Worksheet

TOTAL PART FAILURES, HF,HF-ME

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR	6	8	3	1	4	8	13	13	11	13	80
Non-VR	4	7	3	7	4	1	5	13	14	9	67
TOTAL	10	15	6	8	8	9	18	26	25	22	147
FLYING HOURS											
VR	49633	45573	44888	51546	56209	59964	61296	60023	53587	53899	536618
Non-VR	62444	57049	47979	45773	43217	44016	44950	43727	40191	44134	473480
TOTAL	112077	102622	92867	97319	99426	103980	106246	103750	93778	98033	1010098

TOTAL PART FAILURES, HF, HF-ME PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR											
C-130	0	0	0	0	1	2	6	3	6	6	24
C-9	6	8	3	1	3	6	6	8	4	6	51
C-20	0	0	0	0	0	0	1	2	1	1	5
Non-VR											
C-130	4	7	3	6	4	1	5	10	14	9	63
C-9	0	0	0	1	0	0	0	0	0	0	1
C-20	0	0	0	0	0	0	0	3	0	0	3
FLYING HOURS											
VR											
C-130	22	396	2900	6426	10214	13199	13567	13891	13726	14723	89064
C-9	48174	44017	40527	43975	43710	41616	41232	38357	33135	34177	408920
C-20	1437	1160	1461	1145	2285	5149	6497	7775	6726	4999	38634
Non-VR											
C-130	58921	53641	45069	42673	40431	41008	41555	40345	37980	41311	442934
C-9	3504	3394	2898	3063	2730	2647	2545	2188	1909	2823	27701
C-20	19	14	12	37	56	361	850	1194	302	0	2845

RATIO

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR	0.00012089	0.000176	6.68E-05	1.94E-05	7.12E-05	0.000133	0.000212	0.000217	0.000205	0.000241	0.000149
Non-VR	6.4057E-05	0.000123	6.25E-05	0.000153	9.26E-05	2.27E-05	0.000111	0.000297	0.000348	0.000204	0.000142

RATIO PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR											
C-130	0	0	0	0	9.79E-05	0.000152	0.000442	0.000216	0.000437	0.000408	0.000269
C-9	0.00012455	0.000182	7.4E-05	2.27E-05	6.86E-05	0.000144	0.000146	0.000209	0.000121	0.000176	0.000125
C-20	0	0	0	0	0	0	0.000154	0.000257	0.000149	0.0002	0.000129
Non-VR											
C-130	6.7888E-05	0.00013	6.66E-05	0.000141	9.89E-05	2.44E-05	0.00012	0.000248	0.000369	0.000218	0.000142
C-9	0	0	0	0.000326	0	0	0	0	0	0	3.61E-05
C-20	0	0	0	0	0	0	0	0.002513	0	#DIV/0!	0.001054

Figure B-3. TPF, Human Factor, HFACS-ME Tally/Flying Hour Worksheet

TOTAL PART FAILURES, HF, HF-ME, HF-ME PART FAILURE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR	3	3	2	1	4	8	7	9	8	6	51
Non-VR	0	2	2	2	1	1	3	5	9	5	30
TOTAL	3	5	4	3	5	9	10	14	17	11	81
FLYING HOURS											
VR	49633	45573	44888	51546	56209	59964	61296	60023	53587	53899	536618
Non-VR	62444	57049	47979	45773	43217	44016	44950	43727	40191	44134	473480
TOTAL	112077	102622	92867	97319	99426	103980	106246	103750	93778	98033	1010098

TOTAL PART FAILURES, HF, HF-ME, HF-ME PART FAILURE PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR											
C-130	0	0	0	0	1	2	3	2	4	2	14
C-9	3	3	2	1	3	6	4	7	4	3	36
C-20	0	0	0	0	0	0	0	0	0	1	1
Non-VR											
C-130	0	2	2	2	1	1	3	5	9	5	30
C-9	0	0	0	0	0	0	0	0	0	0	0
C-20	0	0	0	0	0	0	0	0	0	0	0
FLYING HOURS											
VR											
C-130	22	396	2900	6426	10214	13199	13567	13891	13726	14723	89064
C-9	48174	44017	40527	43975	43710	41616	41232	38357	33135	34177	408920
C-20	1437	1160	1461	1145	2285	5149	6497	7775	6726	4999	38634
Non-VR											
C-130	58921	53641	45069	42673	40431	41008	41555	40345	37980	41311	442934
C-9	3504	3394	2898	3063	2730	2647	2545	2188	1909	2823	27701
C-20	19	14	12	37	56	361	850	1194	302	0	2845

RATIO

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR	6.0444E-05	6.58E-05	4.46E-05	1.94E-05	7.12E-05	0.000133	0.000114	0.00015	0.000149	0.000111	9.5E-05
OTHER	0	3.51E-05	4.17E-05	4.37E-05	2.31E-05	2.27E-05	6.67E-05	0.000114	0.000224	0.000113	6.34E-05

RATIO PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR											
C-130	0	0	0	0	9.79E-05	0.000152	0.000221	0.000144	0.000291	0.000136	0.000157
C-9	6.2274E-05	6.82E-05	4.93E-05	2.27E-05	6.86E-05	0.000144	9.7E-05	0.000182	0.000121	8.78E-05	8.8E-05
C-20	0	0	0	0	0	0	0	0	0	0.0002	2.59E-05
Non-VR											
C-130	0	3.73E-05	4.44E-05	4.69E-05	2.47E-05	2.44E-05	7.22E-05	0.000124	0.000237	0.000121	6.77E-05
C-9	0	0	0	0	0	0	0	0	0	0	0
C-20	0	0	0	0	0	0	0	0	0	#DIV/0!	0

Figure B-4. TPF, Human Factor, HFACS-ME, HFACS-ME Part Failure Tally/Flying Hour Worksheet

TOTAL PART FAILURES, HF,HF-ME, SQUADRON

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR	3	8	2	1	1	5	6	7	8	4	45
Non-VR	3	6	3	6	2	1	0	4	7	5	37
TOTAL	6	14	5	7	3	6	6	11	15	9	82

FLYING HOURS

VR	49633	45573	44888	51546	56209	59964	61296	60023	53587	53899	536618
Non-VR	62444	57049	47979	45773	43217	44016	44950	43727	40191	44134	473480
TOTAL	112077	102622	92867	97319	99426	103980	106246	103750	93778	98033	1010098

TOTAL PART FAILURES, HF, HF-ME, SQUADRON PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR											
C-130	0	0	0	0	1	2	2	1	4	1	11
C-9	3	8	2	1	0	3	4	6	3	3	33
C-20	0	0	0	0	0	0	0	0	1	0	1

Non-VR

C-130	3	6	3	6	2	1	0	4	7	5	37
C-9	0	0	0	0	0	0	0	0	0	0	0
C-20	0	0	0	0	0	0	0	0	0	0	0

FLYING HOURS

VR											
C-130	22	396	2900	6426	10214	13199	13567	13891	13726	14723	89064
C-9	48174	44017	40527	43975	43710	41616	41232	38357	33135	34177	408920
C-20	1437	1160	1461	1145	2285	5149	6497	7775	6726	4999	38634

Non-VR

C-130	58921	53641	45069	42673	40431	41008	41555	40345	37980	41311	442934
C-9	3504	3394	2898	3063	2730	2647	2545	2188	1909	2823	27701
C-20	19	14	12	37	56	361	850	1194	302	0	2845

RATIO

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR	6.0444E-05	0.000176	4.46E-05	1.94E-05	1.78E-05	8.34E-05	9.79E-05	0.000117	0.000149	7.42E-05	8.39E-05
Non-VR	4.8043E-05	0.000105	6.25E-05	0.000131	4.63E-05	2.27E-05	0	9.15E-05	0.000174	0.000113	7.81E-05

RATIO PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR											
C-130	0	0	0	0	9.79E-05	0.000152	0.000147	7.2E-05	0.000291	6.79E-05	0.000124
C-9	6.2274E-05	0.000182	4.93E-05	2.27E-05	0	7.21E-05	9.7E-05	0.000156	9.05E-05	8.78E-05	8.07E-05
C-20	0	0	0	0	0	0	0	0	0.000149	0	2.59E-05
Non-VR											
C-130	5.0916E-05	0.000112	6.66E-05	0.000141	4.95E-05	2.44E-05	0	9.91E-05	0.000184	0.000121	8.35E-05
C-9	0	0	0	0	0	0	0	0	0	0	0
C-20	0	0	0	0	0	0	0	0	0	#DIV/0!	0

Figure B-5. Squadron Related TPF, Human Factor, HFACS-ME Tally/Flying Hour Worksheet

TOTAL PART FAILURES, HF,HF-ME, Non-SQUADRON

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR	3	4	1	1	3	4	8	8	4	9	45
Non-VR	1	2	1	5	3	0	5	11	10	4	42
TOTAL	4	6	2	6	6	4	13	19	14	13	87
FLYING HOURS											
VR	49633	45573	44888	51546	56209	59964	61296	60023	53587	53899	536618
Non-VR	62444	57049	47979	45773	43217	44016	44950	43727	40191	44134	473480
TOTAL	112077	102622	92867	97319	99426	103980	106246	103750	93778	98033	1010098

TOTAL PART FAILURES, HF, HF-ME, Non-SQUADRON PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR											
C-130	0	0	0	0	0	0	4	3	3	5	15
C-9	3	4	1	1	3	4	3	3	1	3	26
C-20	0	0	0	0	0	0	1	2	0	1	4
Non-VR											
C-130	1	2	1	4	3	0	5	8	10	4	38
C-9	0	0	0	1	0	0	0	0	0	0	1
C-20	0	0	0	0	0	0	0	3	0	0	3
FLYING HOURS											
VR											
C-130	22	396	2900	6426	10214	13199	13567	13891	13726	14723	89064
C-9	48174	44017	40527	43975	43710	41616	41292	38357	33135	34177	408920
C-20	1437	1160	1461	1145	2285	5149	6497	7775	6726	4999	38634
Non-VR											
C-130	58921	53641	45069	42673	40431	41008	41555	40345	37980	41311	442934
C-9	3504	3394	2898	3063	2730	2647	2545	2188	1909	2823	27701
C-20	19	14	12	37	56	361	850	1194	302	0	2845

RATIO

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR	6.0444E-05	8.78E-05	2.23E-05	1.94E-05	5.34E-05	6.67E-05	0.000131	0.000133	7.46E-05	0.000167	8.39E-05
Non-VR	1.6014E-05	3.51E-05	2.08E-05	0.000109	6.94E-05	0	0.000111	0.000252	0.000249	9.06E-05	8.87E-05

RATIO PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR											
C-130	0	0	0	0	0	0	0.000295	0.000216	0.000219	0.00034	0.000168
C-9	6.2274E-05	9.09E-05	2.47E-05	2.27E-05	6.86E-05	9.61E-05	7.28E-05	7.82E-05	3.02E-05	8.78E-05	6.36E-05
C-20	0	0	0	0	0	0	0.000154	0.000257	0	0.0002	0.000104
Non-VR											
C-130	1.6972E-05	3.73E-05	2.22E-05	9.37E-05	7.42E-05	0	0.00012	0.000198	0.000263	9.68E-05	8.58E-05
C-9	0	0	0	0.000326	0	0	0	0	0	0	3.61E-05
C-20	0	0	0	0	0	0	0	0.002513	0	#DIV/0!	0.001054

Figure B-6. Non-Squadron Related TPF, Human Factor, HFACS-ME Tally/Flying Hour Worksheet

TOTAL PART FAILURES, HF, HF-ME, HF-ME PART FAILURE, SQUADRON

<u>FISCAL YEAR</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>TOTAL</u>
PART FAILURES											
VR	2	3	1	1	1	5	4	6	7	1	31
Non-VR	0	1	2	2	1	1	0	3	6	4	20
TOTAL	2	4	3	3	2	6	4	9	13	5	51
FLYING HOURS											
VR	49633	45573	44888	51546	56209	59964	61296	60023	53587	53899	536618
Non-VR	62444	57049	47979	45773	43217	44016	44950	43727	40191	44134	473480
TOTAL	112077	102622	92867	97319	99426	103980	106246	103750	93778	98033	1010098

TOTAL PART FAILURES, HF, HF-ME, HF-ME PART FAILURE, SQUADRON PER AIRCRAFT TYPE

<u>FISCAL YEAR</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>TOTAL</u>
PART FAILURES											
VR											
C-130	0	0	0	0	1	2	2	1	4	0	10
C-9	2	3	1	1	0	3	2	5	3	1	21
C-20	0	0	0	0	0	0	0	0	0	0	0
Non-VR											
C-130	0	1	2	2	1	1	0	3	6	4	20
C-9	0	0	0	0	0	0	0	0	0	0	0
C-20	0	0	0	0	0	0	0	0	0	0	0
FLYING HOURS											
VR											
C-130	22	396	2900	6426	10214	13199	13567	13891	13726	14723	89064
C-9	48174	44017	40527	43975	43710	41616	41232	38357	33135	34177	408920
C-20	1437	1160	1461	1145	2285	5149	6497	7775	6726	4999	38634
Non-VR											
C-130	58921	53641	45069	42673	40431	41008	41555	40345	37980	41311	442934
C-9	3504	3394	2898	3063	2730	2647	2545	2188	1909	2823	27701
C-20	19	14	12	37	56	361	850	1194	302	0	2845

RATIO

<u>FISCAL YEAR</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>TOTAL</u>
VR	4E-05	6.6E-05	2.2E-05	1.9E-05	1.8E-05	8.3E-05	6.5E-05	1E-04	0.00013	1.9E-05	5.8E-05
Non-VR	0	1.8E-05	4.2E-05	4.4E-05	2.3E-05	2.3E-05	0	6.9E-05	0.00015	9.1E-05	4.2E-05

RATIO PER AIRCRAFT TYPE

<u>FISCAL YEAR</u>	<u>90</u>	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>TOTAL</u>
VR											
C-130	0	0	0	0	9.8E-05	0.00015	0.00015	7.2E-05	0.00029	0	0.00011
C-9	4.2E-05	6.8E-05	2.5E-05	2.3E-05	0	7.2E-05	4.9E-05	0.00013	9.1E-05	2.9E-05	5.1E-05
C-20	0	0	0	0	0	0	0	0	0	0	0
Non-VR											
C-130	0	1.9E-05	4.4E-05	4.7E-05	2.5E-05	2.4E-05	0	7.4E-05	0.00016	9.7E-05	4.5E-05
C-9	0	0	0	0	0	0	0	0	0	0	0
C-20	0	0	0	0	0	0	0	0	0	#DIV/0!	0

Figure B-7. Squadron Related TPF, Human Factors, HFACS-ME, HFACS-ME Part Failure Tally/Flying Hour Worksheet

TOTAL PART FAILURES, HF,HF-ME, HF-ME PART FAILURE, NON-SQUADRON

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR	0	0	1	1	3	4	4	5	2	5	25
Non-VR	0	1	1	2	1	0	3	3	6	1	18
TOTAL	0	1	2	3	4	4	7	8	8	6	43
FLYING HOURS											
VR	49633	45573	44888	51546	56209	59964	61296	60023	53587	53899	536618
Non-VR	62444	57049	47979	45773	43217	44016	44950	43727	40191	44134	473480
TOTAL	112077	102622	92867	97319	99426	103980	106246	103750	93778	98033	1010098

TOTAL PART FAILURES, HF, HF-ME, HF-ME PART FAILURE, NON-SQUADRON PER AIRCRAFT TYPE

FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
PART FAILURES											
VR											
C-130	0	0	0	0	0	0	1	2	1	2	6
C-9	0	0	1	1	3	4	3	3	1	2	18
C-20	0	0	0	0	0	0	0	0	0	1	1
Non-VR											
C-130	0	1	1	2	1	0	3	3	6	1	18
C-9	0	0	0	0	0	0	0	0	0	0	0
C-20	0	0	0	0	0	0	0	0	0	0	0
FLYING HOURS											
VR											
C-130	22	396	2900	6426	10214	13199	13567	13891	13726	14723	89064
C-9	48174	44017	40527	43975	43710	41616	41232	38357	33135	34177	408920
C-20	1437	1160	1461	1145	2285	5149	6497	7775	6726	4999	38634
Non-VR											
C-130	58921	53641	45069	42673	40431	41008	41555	40345	37980	41311	442934
C-9	3504	3394	2898	3063	2730	2647	2545	2188	1909	2823	27701
C-20	19	14	12	37	56	361	850	1194	302	0	2845
RATIO											
FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR	0	0	2.2E-05	1.9E-05	5.3E-05	6.7E-05	6.5E-05	8.3E-05	3.7E-05	9.3E-05	4.7E-05
Non-VR	0	1.8E-05	2.1E-05	4.4E-05	2.3E-05	0	6.7E-05	6.9E-05	0.00015	2.3E-05	3.8E-05
RATIO PER AIRCRAFT TYPE											
FISCAL YEAR	90	91	92	93	94	95	96	97	98	99	TOTAL
VR											
C-130	0	0	0	0	0	0	7.4E-05	0.00014	7.3E-05	0.00014	6.7E-05
C-9	0	0	2.5E-05	2.3E-05	6.9E-05	9.6E-05	7.3E-05	7.8E-05	3E-05	5.9E-05	4.4E-05
C-20	0	0	0	0	0	0	0	0	0	0.0002	2.6E-05
Non-VR											
C-130	0	1.9E-05	2.2E-05	4.7E-05	2.5E-05	0	7.2E-05	7.4E-05	0.00016	2.4E-05	4.1E-05
C-9	0	0	0	0	0	0	0	0	0	0	0
C-20	0	0	0	0	0	0	0	0	0	#DIV/0!	0

Figure B-8. Non-Squadron Related TPF, Human Factors, HFACS-ME, HFACS-ME Part Failure Tally/Flying Hour Worksheet

**APPENDIX C: HIERACHICAL BREAKDOWN GRAPHICAL REPRESENTATION
OF VR WING VS NON-VR**

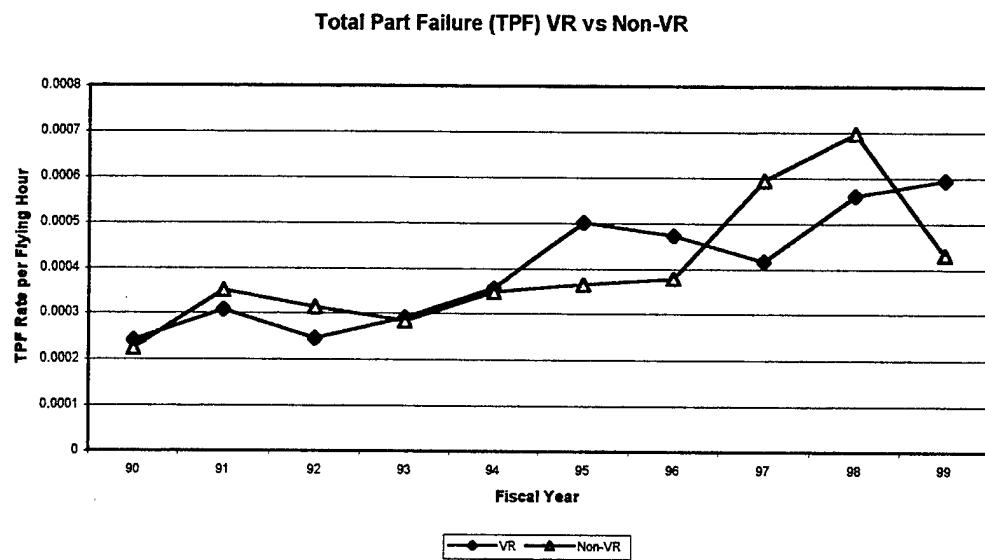


Figure C-1. Total part Failures VR vs Non-VR

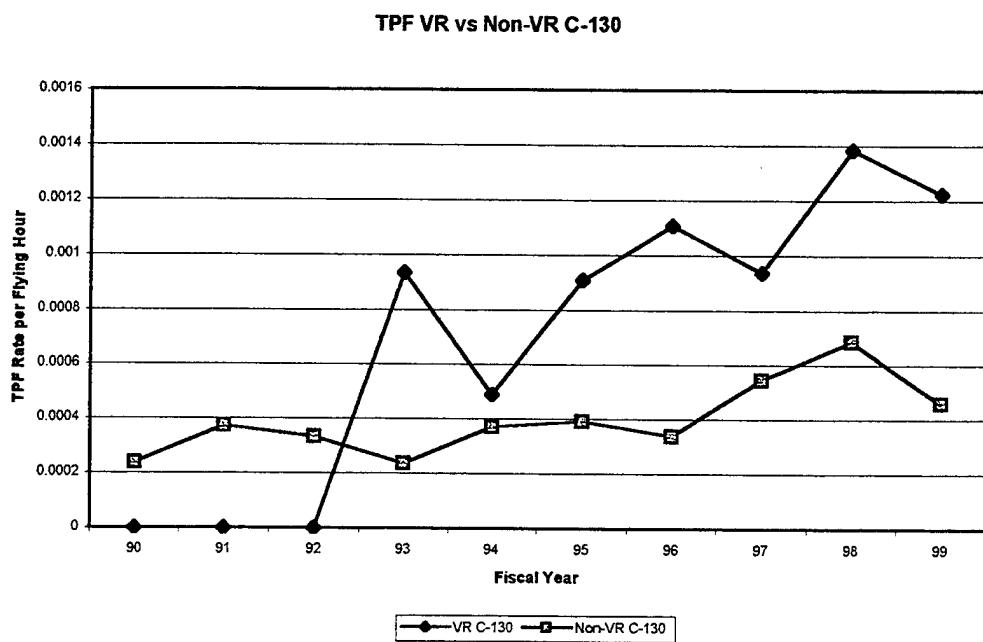


Figure C-2. C-130 Total Part Failures VR vs Non-VR

TPF VR vs Non-VR C-9

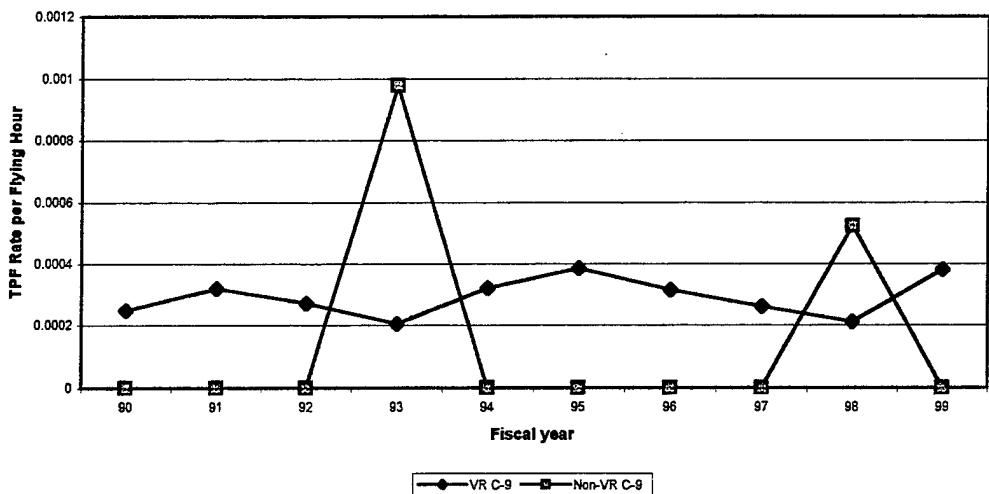


Figure C-3. C-9 Total Part Failures VR vs Non-VR

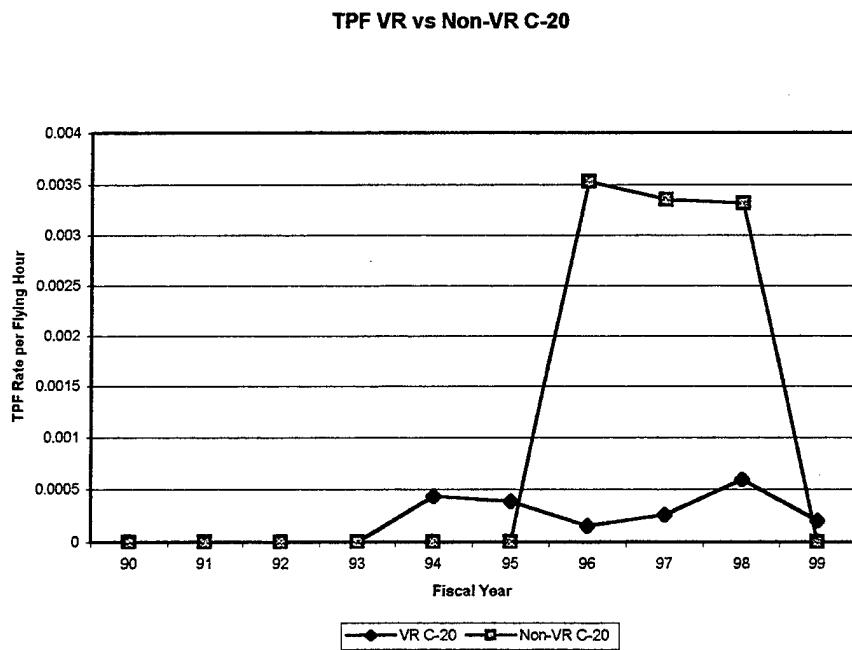


Figure C-4. C-20 Total Part Failures VR vs Non-VR

Human Factor Related (HF) VR vs Non-VR

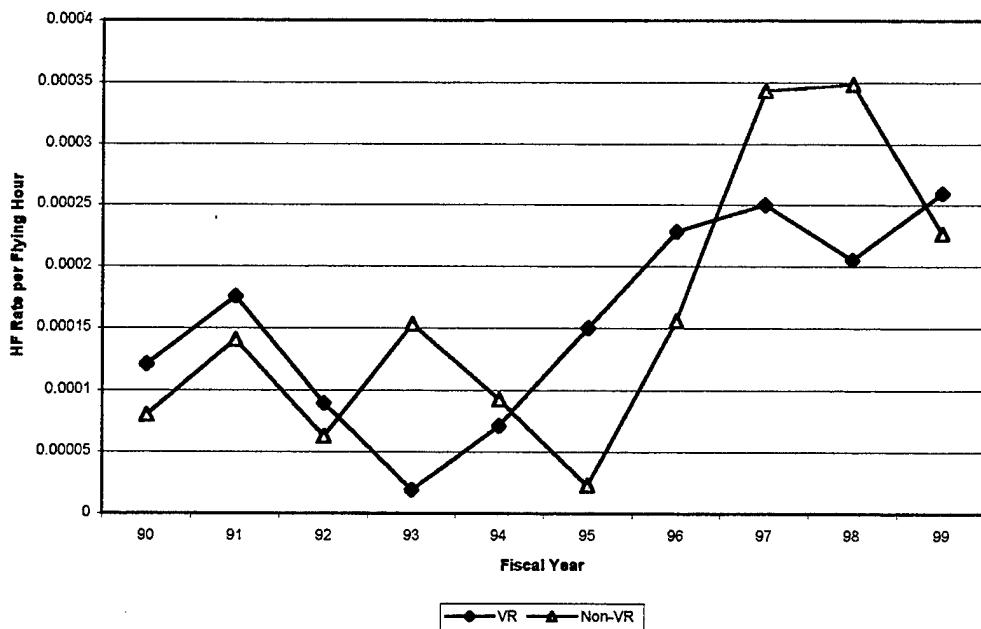


Figure C-5. Human Factor Related VR vs Non-VR

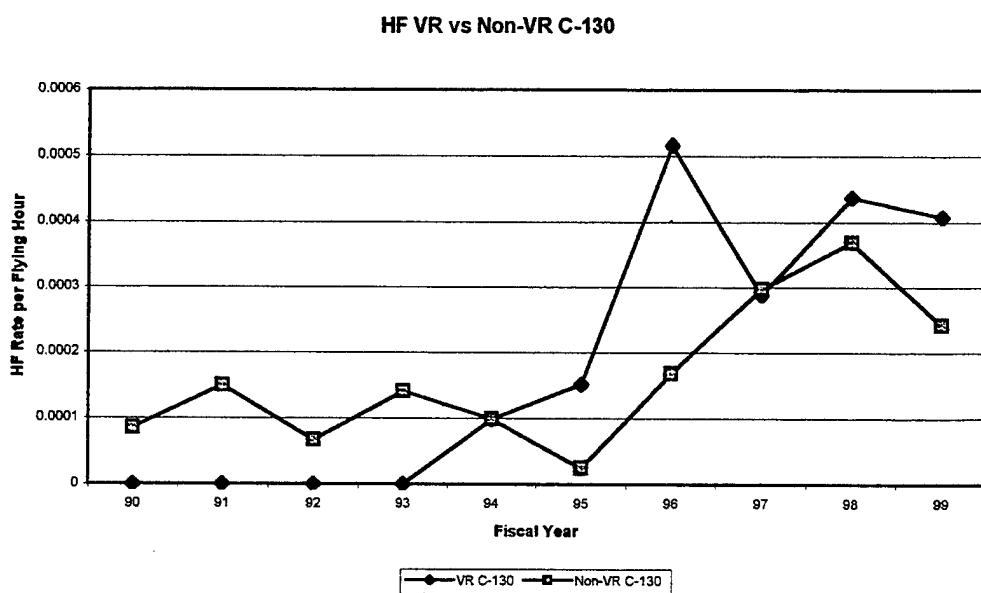


Figure C-6. C-130 Human Factor Related VR vs Non-VR

HF VR vs Non-VR C-9

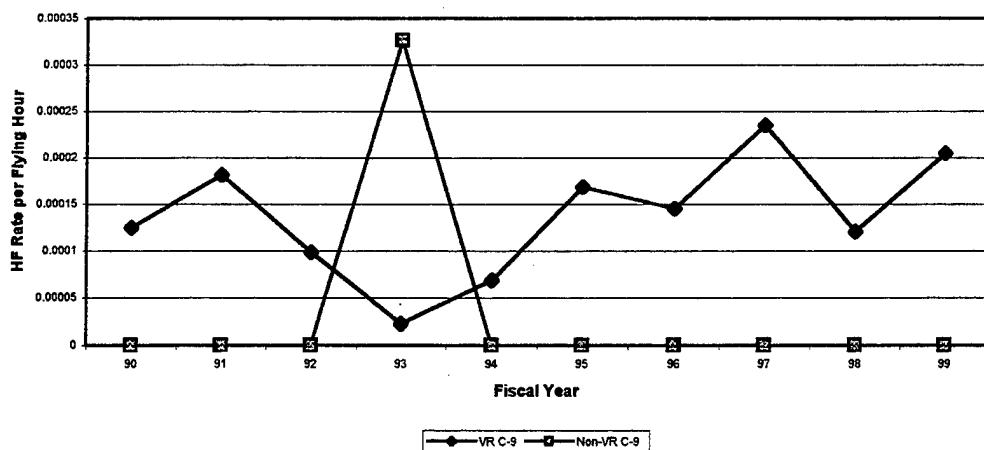


Figure C-7. C-9 Human Factor Related VR vs Non-VR

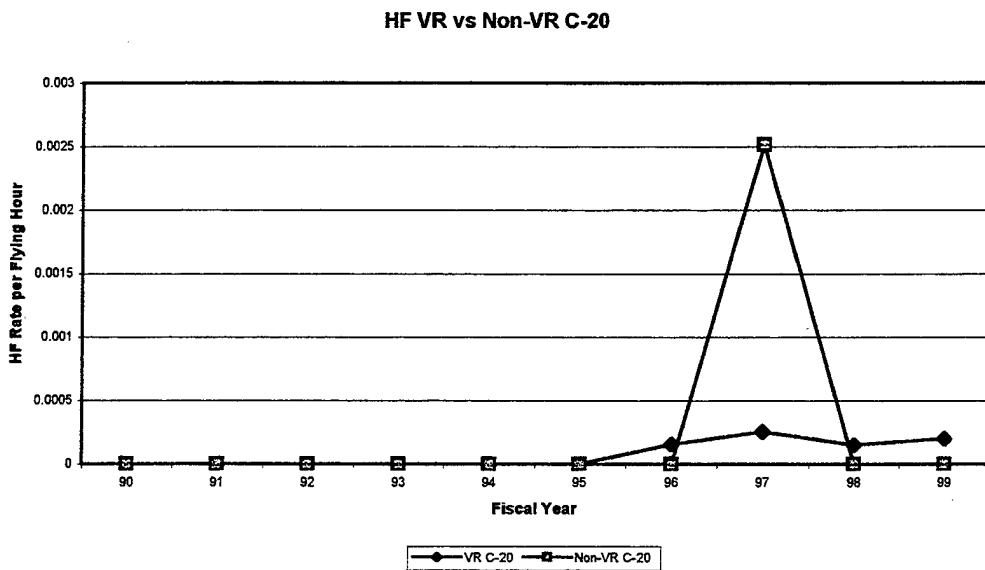


Figure C-8. C-20 Human Factor Related VR vs Non-VR

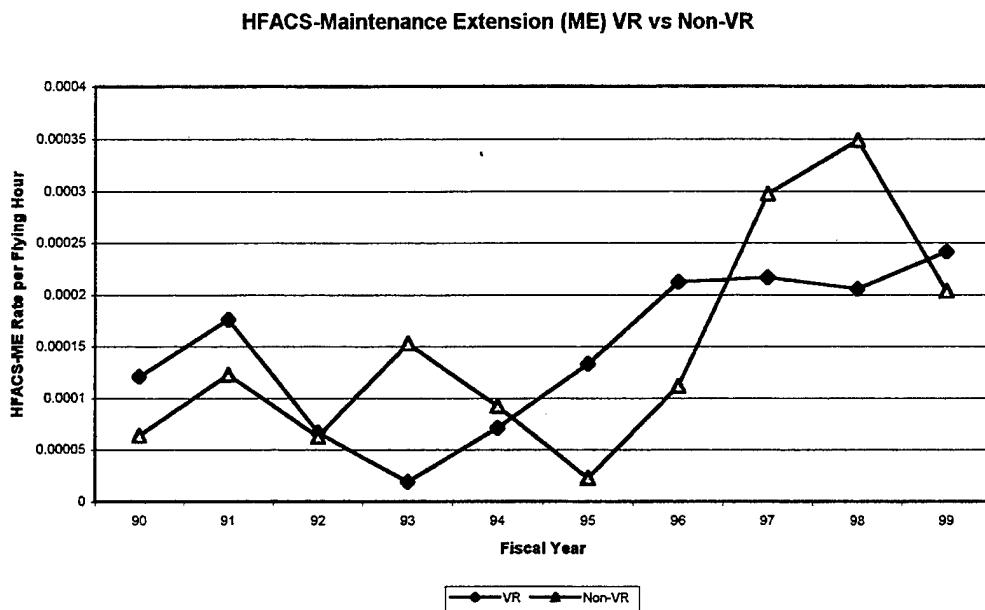


Figure C-9. HFACS-Maintenance Extension Related VR vs Non-VR

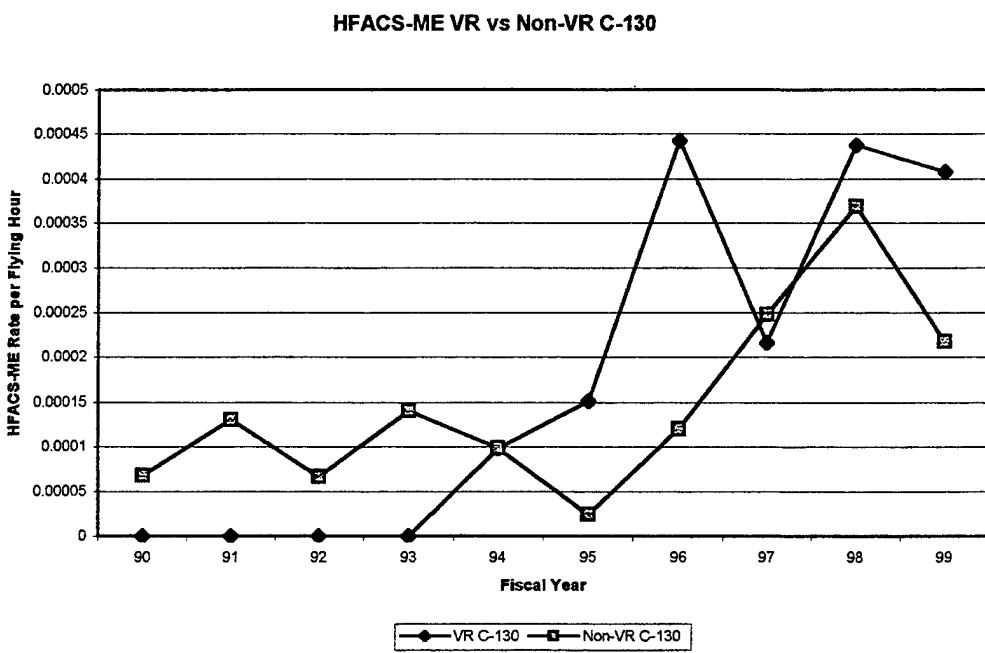


Figure C-10. C-130 HFACS-Maintenance Extension Related VR vs Non-VR

HF-ME VR vs Non-VR C-9

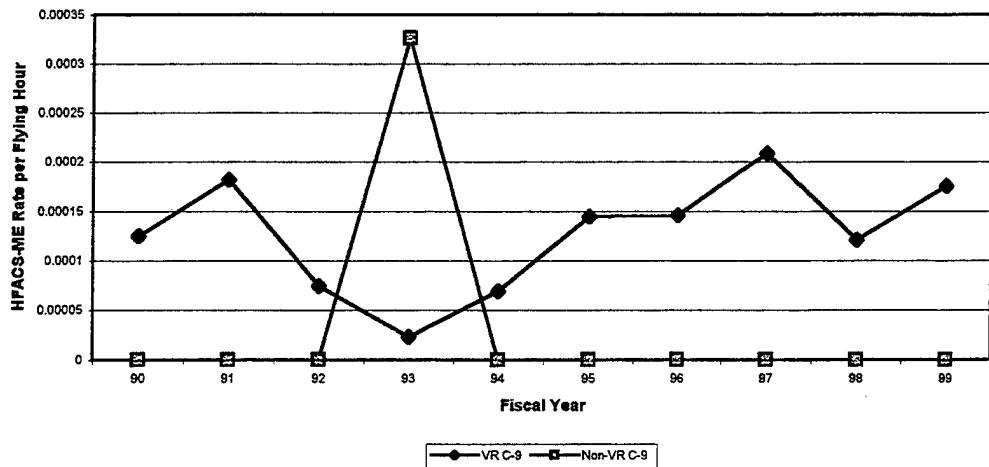


Figure C-11. C-9 HFACS-Maintenance Extension Related VR vs Non-VR

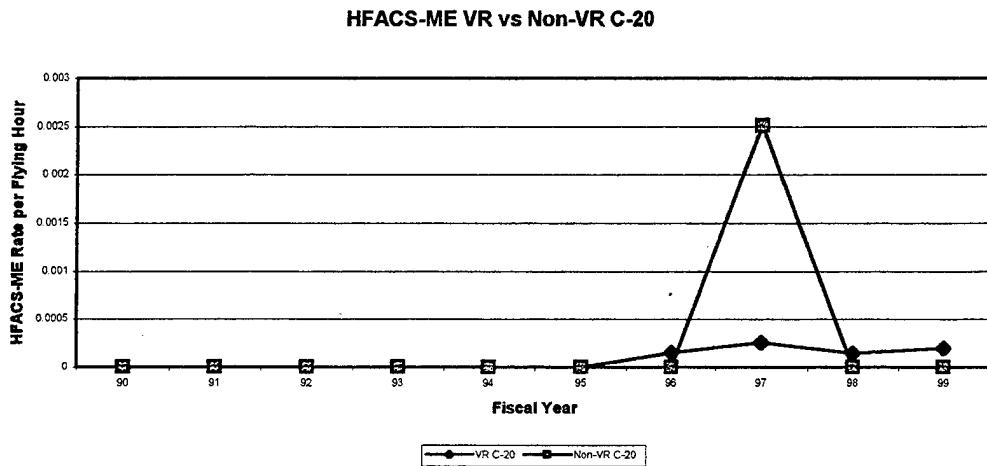


Figure C-12. C-20 HFACS-Maintenance Extension Related VR vs Non-VR

HFACS-ME Part Failure VR vs Non-VR

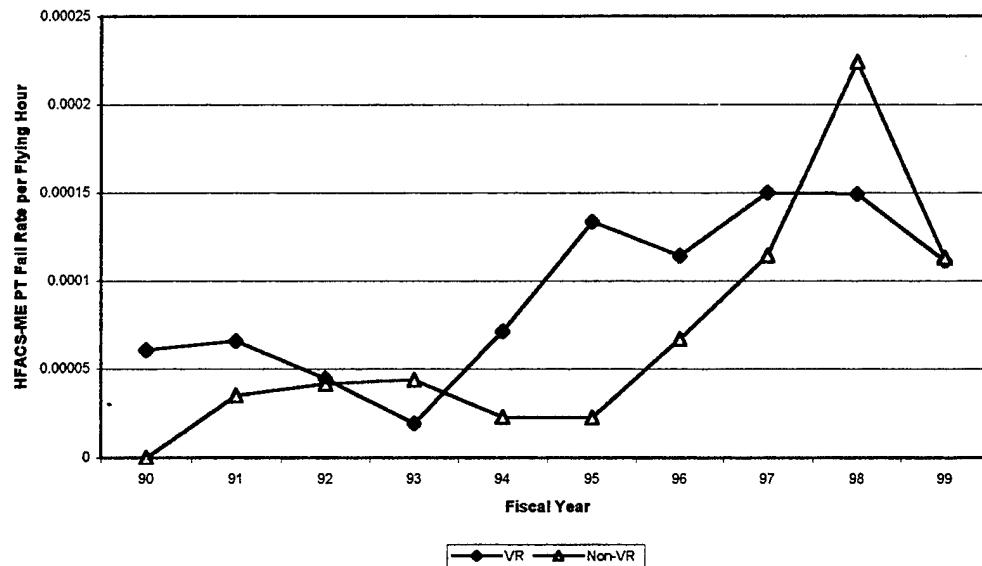


Figure C-13. HFACS-ME Part Failure Related VR vs Non-VR

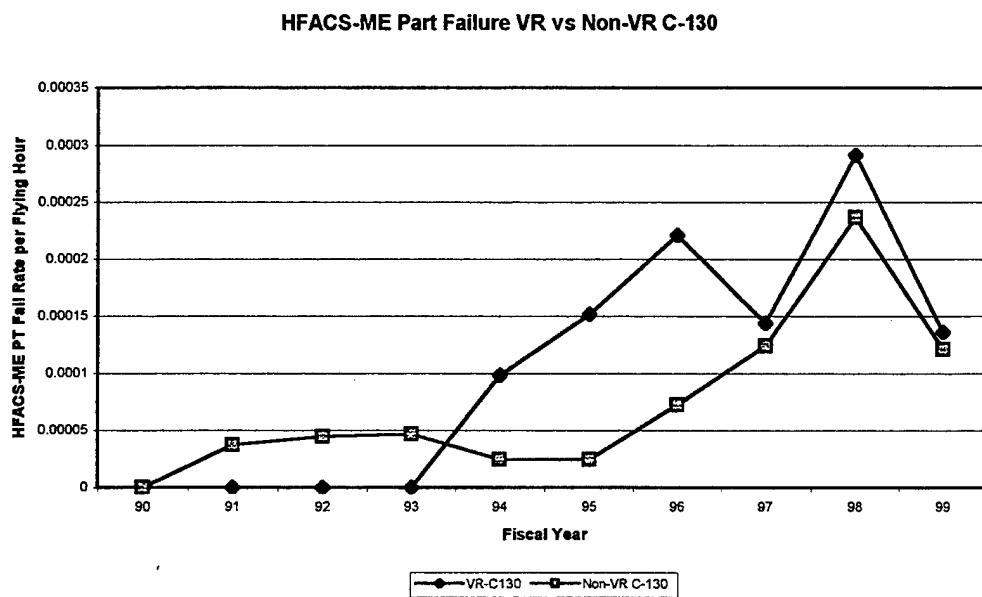


Figure C-14. C-130 HFACS-ME Part Failure Related VR vs Non-VR

HFACS-ME Part Failure VR vs Non-VR C-9

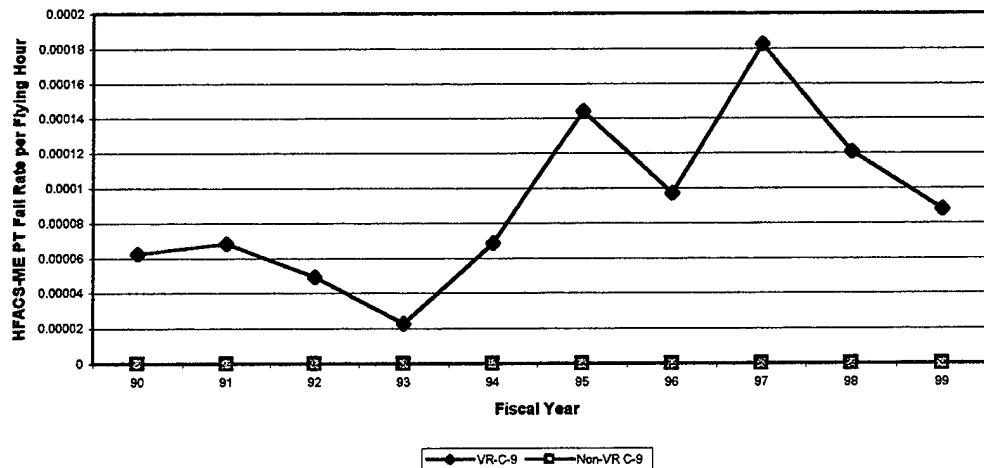


Figure C-15. C-9 HFACS-ME Part Failure Related VR vs Non-VR

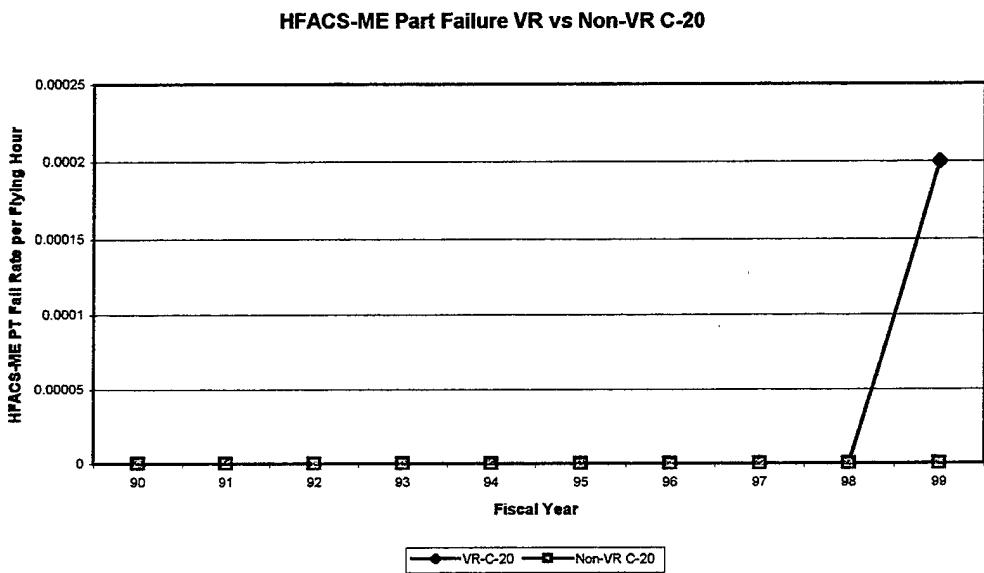


Figure C-16. C-20 HFACS-ME Part Failure Related VR vs Non-VR

Squadron Related HFACS-ME VR vs Non-VR

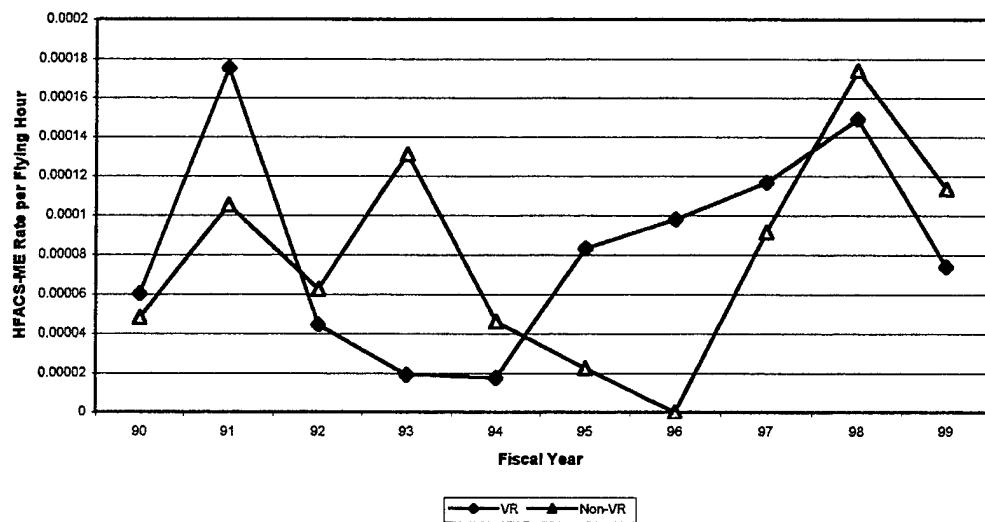


Figure C-17. Squadron Related HFACS-ME VR vs Non-VR

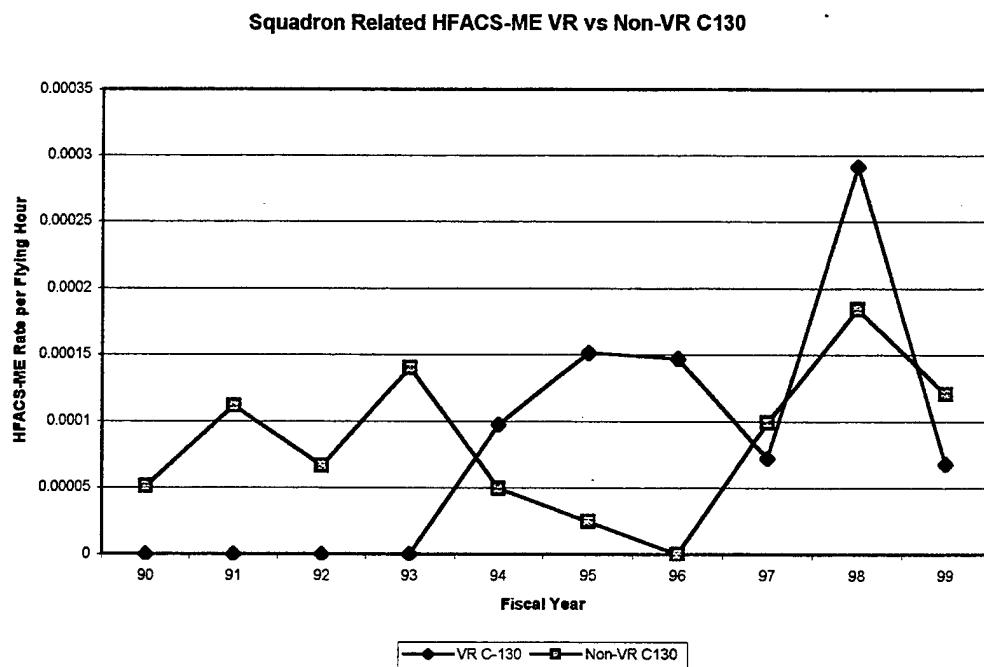


Figure C-18. C-130 Squadron Related HFACS-ME VR vs Non-VR

Squadron Related HFACS-ME VR vs Non-VR C-9

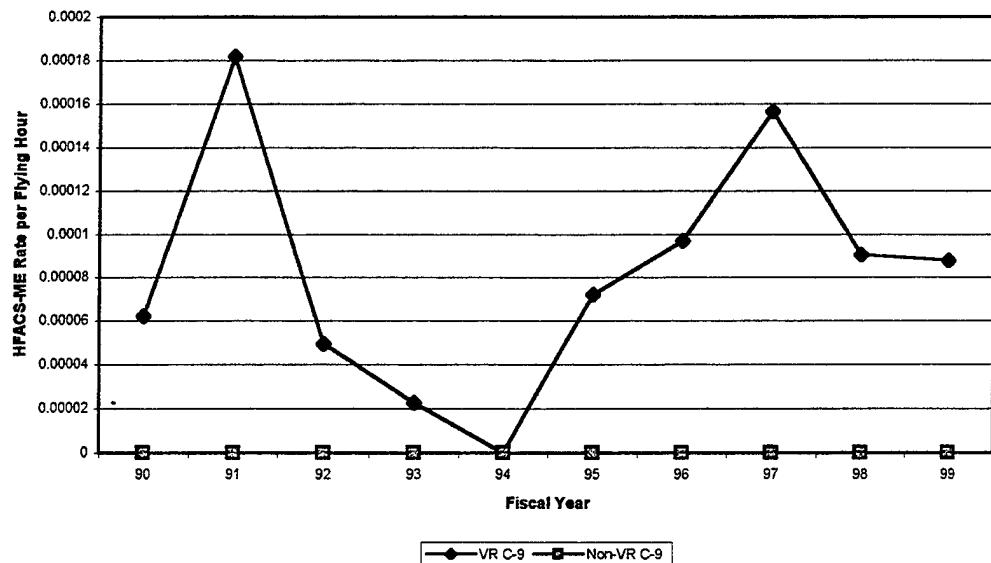


Figure C-19. C-9 Squadron Related HFACS-ME VR vs Non-VR

Squadron Related HFACS-ME VR vs Non-VR C-20

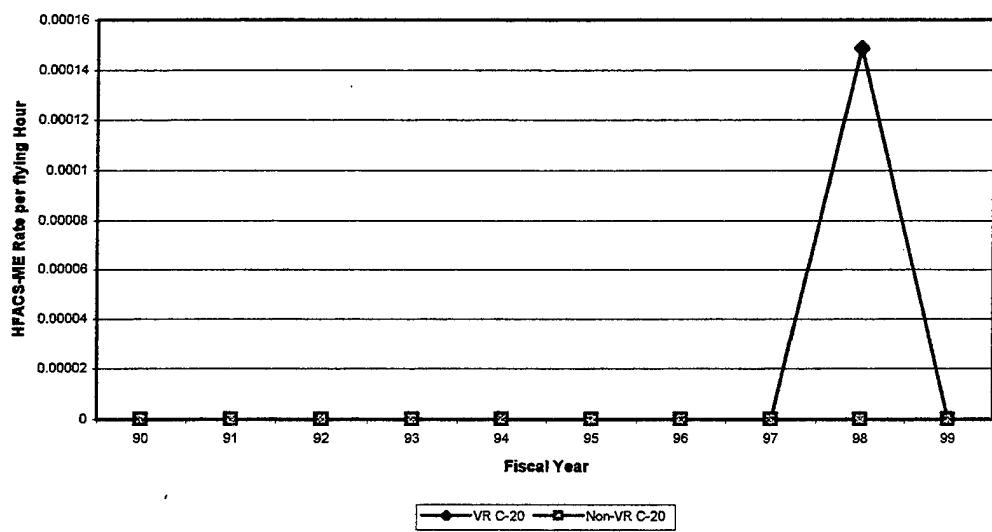


Figure C-20. C-20 Squadron Related HFACS-ME VR vs Non-VR

Non-Squadron Related HFACS-ME VR vs Non-VR

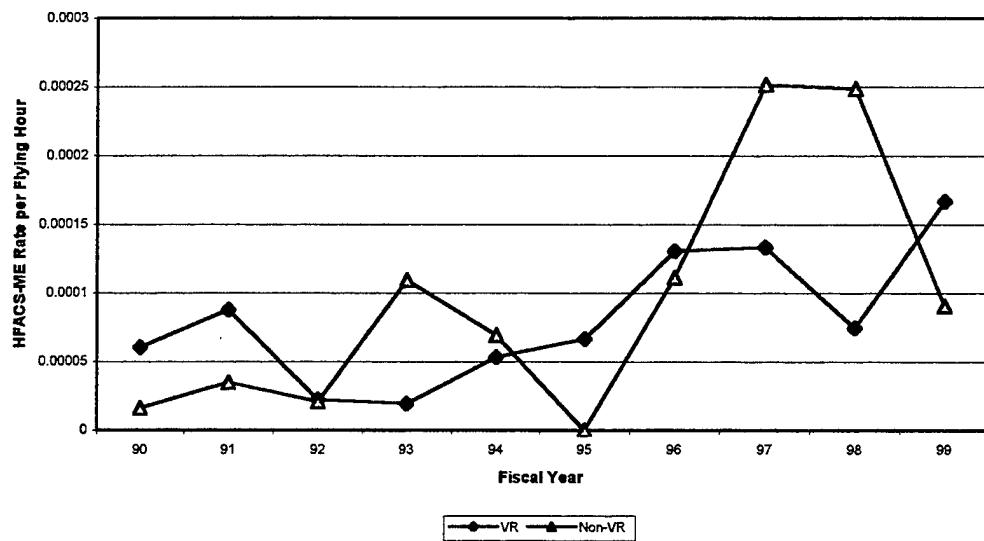


Figure C-21. Non-Squadron Related HFACS-ME VR vs Non-VR

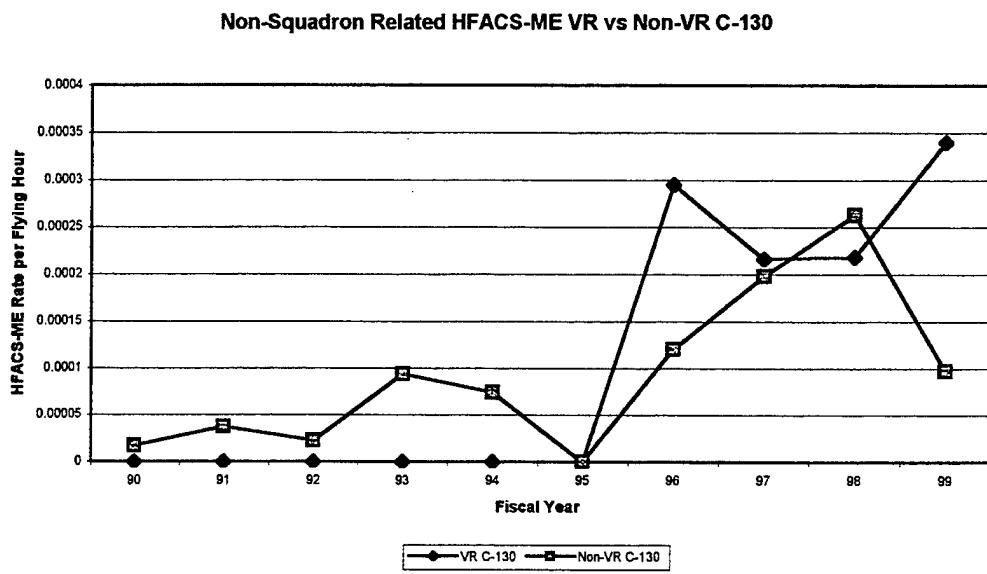


Figure C-22. C-130 Non-Squadron Related HFACS-ME VR vs Non-VR

Non-Squadron Related HFACS-ME VR vs Non-VR C-9

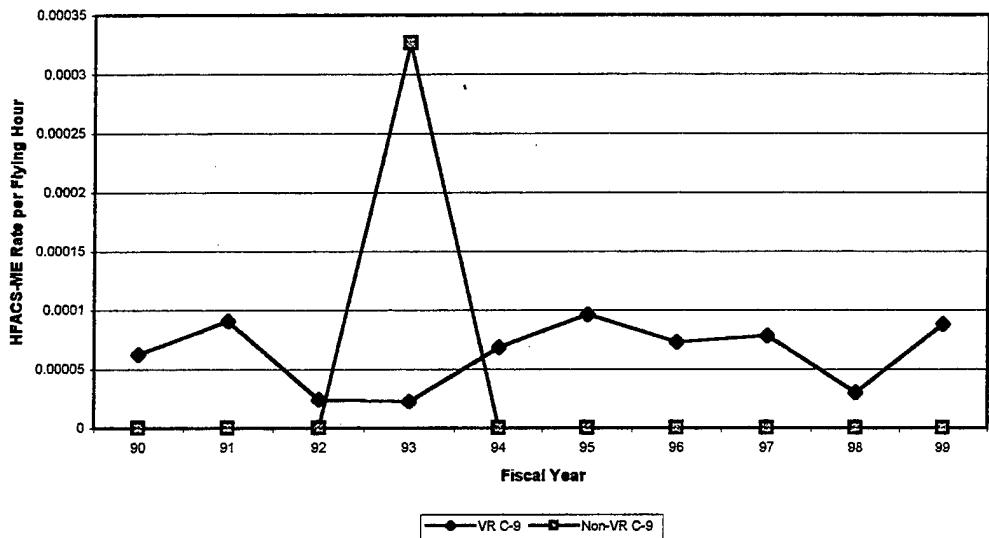


Figure C-23. C-9 Non-Squadron Related HFACS-ME VR vs Non-VR

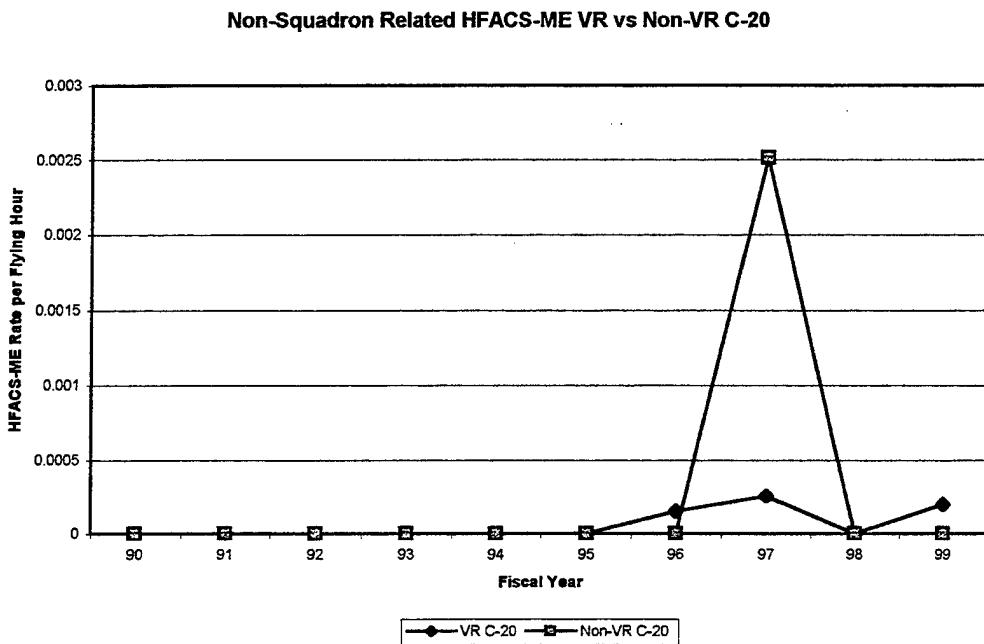


Figure C-24. C-20 Non-Squadron Related HFACS-ME VR vs Non-VR

Squadron HFACS-ME Part Failure VR vs Non-VR

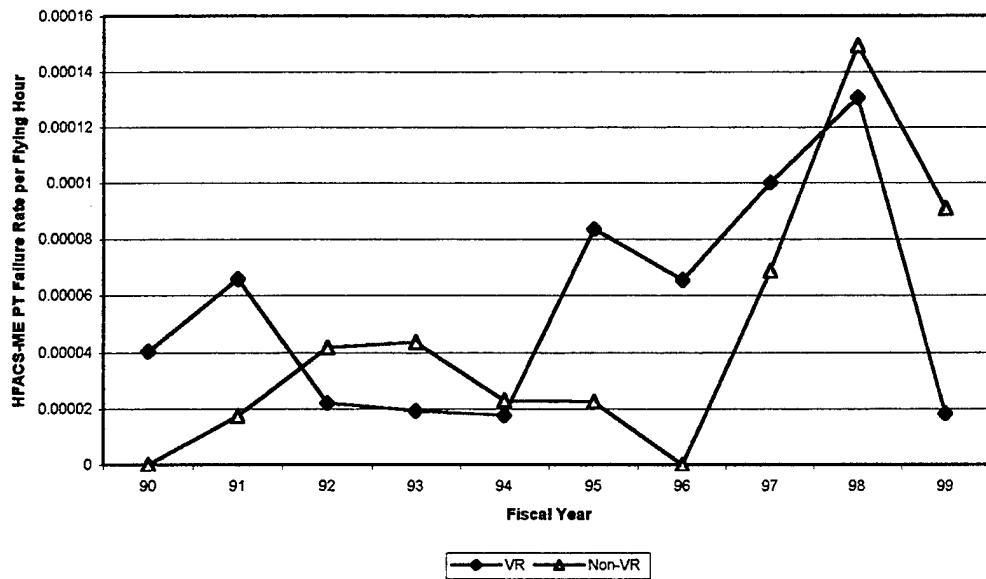


Figure C-25. Squadron Related HFACS-ME Part Failure VR vs Non-VR

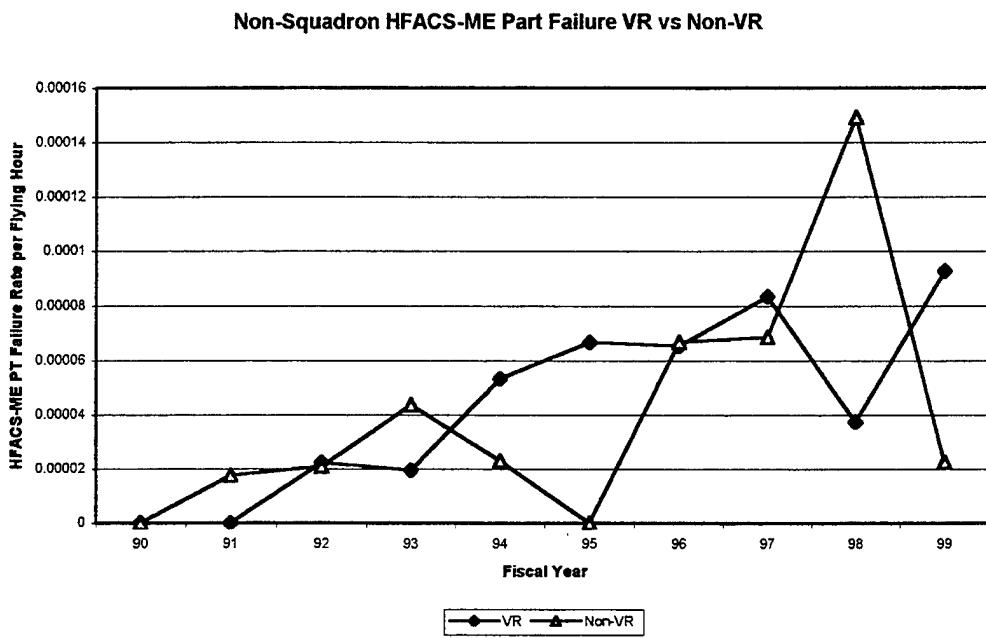


Figure C-26. Non-Squadron Related HFACS-ME Part Failure VR vs Non-VR

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APPENDIX D: REGRESSION ANALYSIS

Total Part Failure Regression

Fiscal Year			FISCAL YEAR		VR	OTHER
	VR	Non-VR				
90	2.41774626	2.24200884	90		0.00024177	0.0002242
91	3.07199438	3.505758208	91		0.0003072	0.00035058
92	2.45054358	3.126367786	92		0.00024505	0.00031264
93	2.91002212	2.840102244	93		0.000291	0.00028401
94	3.55814905	3.470856376	94		0.00035581	0.00034709
95	5.0030018	3.635041803	95		0.0005003	0.0003635
96	4.73114069	3.781979978	96		0.00047311	0.0003782
97	4.16507006	5.945983031	97		0.00041651	0.0005946
98	5.59837274	6.966733846	98		0.00055984	0.00069667
99	5.93703037	4.30507092	99		0.0005937	0.00043051

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.92093558
R Square	0.84812234
Adjusted R Square	0.82913763
Standard Error	0.53401365
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	12.73970285	12.7397	44.674	0.000155271
Residual	8	2.2813646	0.28517		
Total	9	15.02106745			
	Coefficients	Standard Error	t Stat	P-value	
Intercept	-33.150783	5.558501199	-5.964	0.00034	
Fiscal Year	0.39296392	0.058792968	6.68386	0.00016	

NON-VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.7647008
R Square	0.58476732
Adjusted R Square	0.53286323
Standard Error	0.98208845
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	10.86632674	10.8663	11.2663	0.009983028
Residual	8	7.715981818	0.9645		
Total	9	18.58230855			
	Coefficients	Standard Error	t Stat	P-value	
Intercept	-30.314226	10.22247253	-2.9654	0.018	
Fiscal Year	0.36292293	0.10812438	3.35653	0.00998	

Figure D-1. Total Part Failure Regression Output

Total Part Failure Regression C-130

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0	2.376062864	90	0	0.0002376
91	0	3.728491266	91	0	0.0003728
92	0	3.328230047	92	0	0.0003328
93	9.33706816	2.343402151	93	0.000933707	0.0002343
94	4.89524182	3.710024486	94	0.000489524	0.000371
95	9.09159785	3.901677721	95	0.00090916	0.0003902
96	11.0562394	3.369028998	96	0.001105624	0.0003369
97	9.3585775	5.45296815	97	0.000935858	0.0005453
98	13.842343	6.845708268	98	0.001384234	0.0006846
99	12.2257692	4.599259277	99	0.001222577	0.0004599

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.72752294
R Square	0.52928963
Adjusted R Square	0.43514755
Standard Error	2.13817328
Observations	7

ANOVA

	df	SS	MS	F	Significance F
Regression	1	25.70368669	25.7036867	5.622243	0.063863378
Residual	5	22.85892493	4.57178499		
Total	6	48.56261162			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-82.006858	38.79978717	-2.1135904	0.088219
Fiscal Year	0.95811733	0.404076769	2.37112697	0.063863

NON-VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.76183733
R Square	0.58039612
Adjusted R Square	0.49647535
Standard Error	1.04846901
Observations	7

ANOVA

	df	SS	MS	F	Significance F
Regression	1	7.60267118	7.60267118	6.916	0.046542855
Residual	5	5.496436273	1.09928725		
Total	6	13.09910745			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-45.706205	19.02576119	-2.4023325	0.061443
Fiscal Year	0.52107962	0.198142017	2.62982898	0.046543

Figure D-2. Total Part Failure C-130 Regression Output

Total Part Failure Regression C-9

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	2.49097023	0	90	0.000249097	0
91	3.18058932	0	91	0.000318059	0
92	2.71423989	0	92	0.000271424	0
93	2.0466174	9.794319295	93	0.000204662	0.0009794
94	3.20292839	0	94	0.000320293	0
95	3.84467512	0	95	0.000384468	0
96	3.15289096	0	96	0.000315289	0
97	2.60708606	0	97	0.000260709	0
98	2.11256979	5.238344683	98	0.000211257	0.0005238
99	3.80372765	0	99	0.000380373	0

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.22596242
R Square	0.05105902
Adjusted R Squ	-0.0675586
Standard Error	0.65138502
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.182641201	0.1826412	0.43045051	0.530181526
Residual	8	3.394419517	0.42430244		
Total	9	3.577060717			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-1.5307263	6.780209486	-0.2257639	0.82704596
Fiscal Year	0.04705138	0.07171513	0.65608727	0.53018153

Figure D-3. Total Part Failure C-9 Regression Output

Total Part Failure Regression C-20

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0	0	90	0	0
91	0	0	91	0	0
92	0	0	92	0	0
93	0	0	93	0	0
94	4.37636761	0	94	0.000437637	0
95	3.88424937	0	95	0.000388425	0
96	1.53917193	35.29411765	96	0.000153917	0.0035294
97	2.57234727	33.50083752	97	0.000257235	0.0033501
98	5.94707107	33.11258278	98	0.000594707	0.0033113
99	2.00040008	10000	99	0.00020004	#DIV/0!

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.14997911
R Square	0.02249373
Adjusted R Squa	-0.2218828
Standard Error	1.83513434
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.309982879	0.30998	0.09204538	0.776718131
Residual	4	13.47087226	3.36772		
Total	5	13.78085514			

	Coefficients	Standard Error	t Stat	P-value
Intercept	16.2299165	42.33934682	0.38333	0.72097742
Fiscal Year	-0.1330913	0.438681014	-0.3034	0.77671813

Figure D-4. Total Part Failure C-20 Regression Output

Human Factor Regression

Fiscal Year	VR		Non-VR		FISCAL YEAR		
		OTHER		OTHER	VR	OTHER	
90	1.20887313	0.800717443			90	0.000120887	8E-05
91	1.75542536	1.402303283			91	0.000175543	0.00014
92	0.89110675	0.625273557			92	8.91107E-05	6.3E-05
93	0.19400147	1.529285824			93	1.94001E-05	0.00015
94	0.71162981	0.9255617			94	7.1163E-05	9.3E-05
95	1.50090054	0.227190113			95	0.00015009	2.3E-05
96	2.28399896	1.557285873			96	0.0002284	0.00016
97	2.49904203	3.430374826			97	0.000249904	0.00034
98	2.05273667	3.483366923			98	0.000205274	0.00035
99	2.59745079	2.2658268			99	0.000259745	0.00023

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.6713125
R Square	0.45066047
Adjusted R Squa	0.38199303
Standard Error	0.63770287
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	2.668918739	2.66891874	6.56294258	0.033551613
Residual	8	3.253319629	0.40666495		
Total	9	5.922238368			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-15.427483	6.637793251	-2.32419	0.0486005
Fiscal Year	0.17986253	0.070208776	2.56182407	0.03355161

NON-VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.67383979
R Square	0.45406007
Adjusted R Squa	0.38581757
Standard Error	0.87849105
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	5.134913268	5.13491327	6.65362673	0.032643593
Residual	8	6.173972154	0.77174652		
Total	9	11.30888542			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-21.95135	9.144136232	-2.4005931	0.04313679
Fiscal Year	0.24948221	0.096718681	2.57946249	0.03264359

Figure D-5. Human Factor Regression Output

Human Factor Regression C-130

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0	0.84859388	90	0	8.4859E-05
91	0	1.491396506	91	0	0.00014914
92	0	0.665646009	92	0	6.6565E-05
93	0	1.406041291	93	0	0.0001406
94	0.97905	0.989339863	94	9.79048E-05	9.8934E-05
95	1.51527	0.243854858	95	0.000151527	2.4385E-05
96	5.15958	1.684514499	96	0.000515958	0.00016845
97	2.87956	2.974346263	97	0.000287956	0.00029743
98	4.37127	3.686150606	98	0.000437127	0.00036862
99	4.07526	2.420662777	99	0.000407526	0.00024207

VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.69931
R Square	0.48903
Adjusted R Squa	0.36129
Standard Error	1.32981
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	1	6.769862821	6.76986282	3.8282479	0.122030815
Residual	4	7.073588755	1.76839719		
Total	5	13.84345158			

	Coefficient	Standard Error	t Stat	P-value
Intercept	-56.857	30.68076601	-1.8531799	0.13748204
Fiscal Year	0.62197	0.317885621	1.95659089	0.12203081

NON-VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.78481
R Square	0.61592
Adjusted R Squa	0.51991
Standard Error	0.88594
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	1	5.034829339	5.03482934	6.41462699	0.064478443
Residual	4	3.139592901	0.78489823		
Total	5	8.17442224			

	Coefficient	Standard Error	t Stat	P-value
Intercept	-49.761	20.44009755	-2.4344772	0.07163391
Fiscal Year	0.53638	0.211781319	2.53271139	0.06447844

Figure D-6. Human Factor C-130 Regression Output

Human Factor Regression C-9

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	1.24548512	0	90	0.000124549	0
91	1.81747961	0	91	0.000181748	0
92	0.98699632	0	92	9.86996E-05	0
93	0.22740193	3.264773098	93	2.27402E-05	0.0003265
94	0.6863418	0	94	6.86342E-05	0
95	1.68204537	0	95	0.000168205	0
96	1.45518044	0	96	0.000145518	0
97	2.34637745	0	97	0.000234638	0
98	1.20718274	0	98	0.000120718	0
99	2.04816104	0	99	0.000204816	0

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.41403892
R Square	0.17142823
Adjusted R Squa	0.06785676
Standard Error	0.61734305
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.630805275	0.63080528	1.65516844	0.234235969
Residual	8	3.048899489	0.38111244		
Total	9	3.679704765			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-6.8930153	6.425869601	-1.0726977	0.31469587
Fiscal Year	0.08744212	0.067967232	1.2865335	0.23423597

Figure D-7. Human Factor C-9 Regression Output

Human Factor Regression C-20

Fiscal Year	VR	Non-VR	FISCAL YEAR		OTHER
			VR	90	
90	0	0		90	0
91	0	0		91	0
92	0	0		92	0
93	0	0		93	0
94	0	0		94	0
95	0	0		95	0
96	1.53917193	0		96	0.000153917
97	2.57234727	25.12562814		97	0.000257235
98	1.48676777	0		98	0.000148677
99	2.00040008	10000		99	0.00020004
					#DIV/0!

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.07630742
R Square	0.00582282
Adjusted R Squa	-0.4912658
Standard Error	0.61589165
Observations	4

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.004443328	0.00444333	0.01171385	0.923692576
Residual	2	0.758645042	0.37932252		
Total	3	0.76308837			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-1.0068516	26.85668955	-0.0374898	0.97350003
Fiscal Year	0.0298105	0.275435118	0.10823056	0.92369258

Figure D-8. Human Factor C-20 Regression Output

Human Factor Maintenance Extension Regression

FISCAL YEAR					
Fiscal Year	VR	Non-VR	VR	OTHER	
90	1.208873	0.640574	90	0.000121	6.41E-05
91	1.755425	1.227015	91	0.000176	0.000123
92	0.66833	0.625274	92	6.68E-05	6.25E-05
93	0.194001	1.529286	93	1.94E-05	0.000153
94	0.71163	0.925562	94	7.12E-05	9.26E-05
95	1.334134	0.22719	95	0.000133	2.27E-05
96	2.120856	1.112347	96	0.000212	0.000111
97	2.165836	2.972992	97	0.000217	0.000297
98	2.052737	3.483367	98	0.000205	0.000348
99	2.411919	2.039244	99	0.000241	0.000204

VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.650191
R Square	0.422749
Adjusted R	0.350592
Standard E	0.609482
Observatio	10

ANOVA

	df	SS	MS	F	ignificance F
Regressior	1	2.176353	2.176353	5.858784	0.041818
Residual	8	2.971747	0.371468		
Total	9	5.1481			

	Coefficients	standard Err	t Stat	P-value
Intercept	-13.8863	6.344045	-2.18886	0.060027
Fiscal Yea	0.162419	0.067102	2.420493	0.041818

NON-VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.662208
R Square	0.43852
Adjusted R	0.368335
Standard E	0.840649
Observatio	10

ANOVA

	df	SS	MS	F	ignificance F
Regressior	1	4.415435	4.415435	6.248051	0.036964
Residual	8	5.653519	0.70669		
Total	9	10.06895			

	Coefficients	standard Err	t Stat	P-value
Intercept	-20.3838	8.750236	-2.32951	0.048198
Fiscal Yea	0.231345	0.092552	2.49961	0.036964

Figure D-9. HFACS-Maintenance Extension (ME) Regression Output

Human Factor Maintenance Extension Regression C-130

Fiscal Year	FISCAL YEAR				
	VR	Non-VR	VR		
90	0	0.678875104	90	0	6.8E-05
91	0	1.304971943	91	0	0.00013
92	0	0.665646009	92	0	6.7E-05
93	0	1.406041291	93	0	0.00014
94	0.97904836	0.989339863	94	9.79048E-05	9.9E-05
95	1.51526631	0.243854858	95	0.000151527	2.4E-05
96	4.42249576	1.203224642	96	0.00044225	0.00012
97	2.15967173	2.478621886	97	0.000215967	0.00025
98	4.37126621	3.686150606	98	0.000437127	0.00037
99	4.0752564	2.1785965	99	0.000407526	0.00022

VR REGRESSION

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.75116547
R Square	0.56424957
Adjusted R Squa	0.45531196
Standard Error	1.14415821
Observations	6

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	6.78056002	6.78056002	5.17956637	0.085174186
Residual	4	5.236392029	1.30909801		
Total	5	12.01695205			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	-57.147209	26.39747403	-2.1648741	0.09636151
Fiscal Year	0.62246331	0.273506125	2.27586607	0.08517419

NON-VR REGRESSION

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.7610143
R Square	0.57914277
Adjusted R Squa	0.47392846
Standard Error	0.89399942
Observations	6

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	4.399317533	4.39931753	5.50441076	0.078846511
Residual	4	3.196939852	0.79923496		
Total	5	7.596257386			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	-46.587277	20.62592943	-2.2586753	0.08680757
Fiscal Year	0.50138765	0.213706737	2.34614807	0.07884651

Figure D-10. HFACS-ME C-130 Regression Output

Human Factor Maintenance Extension Regression C-9

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	1.24548512	0	90	0.000124549	0
91	1.81747961	0	91	0.000181748	0
92	0.74024724	0	92	7.40247E-05	0
93	0.22740193	3.264773098	93	2.27402E-05	0.0003265
94	0.6863418	0	94	6.86342E-05	0
95	1.44175317	0	95	0.000144175	0
96	1.45518044	0	96	0.000145518	0
97	2.08566885	0	97	0.000208567	0
98	1.20718274	0	98	0.000120718	0
99	1.75556661	0	99	0.000175557	0

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.36638891
R Square	0.13424083
Adjusted R Squ ^e	0.02602093
Standard Error	0.56763184
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.399678714	0.39967871	1.24044501	0.29772617
Residual	8	2.577647284	0.32220591		
Total	9	2.977325999			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-5.3112615	5.908430065	-0.8989294	0.39494094
Fiscal Year	0.06960309	0.062494209	1.11375267	0.29772617

Figure D-11. HFACS-ME C-9 Regression Output

Human Factor Maintenance Extension Regression C-20

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0	0	90	0	0
91	0	0	91	0	0
92	0	0	92	0	0
93	0	0	93	0	0
94	0	0	94	0	0
95	0	0	95	0	0
96	1.53917193	0	96	0.000153917	0
97	2.57234727	25.12562814	97	0.000257235	0.0025126
98	1.48676777	0	98	0.000148677	0
99	2.00040008	10000	99	0.00020004	#DIV/0!

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.07630742
R Square	0.00582282
Adjusted R Squa	-0.4912658
Standard Error	0.61589165
Observations	4

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.004443328	0.00444333	0.01171385	0.923692576
Residual	2	0.758645042	0.37932252		
Total	3	0.76308837			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%
Intercept	-1.0068516	26.85668955	-0.0374898	0.97350003	-116.561941
Fiscal Year	0.0298105	0.275435118	0.10823056	0.92369258	-1.15529199

Figure D-12. HFACS-ME C-20 Regression Output

HF-ME Part Failure Regression

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0.604437	0	90	6.04E-05	0
91	0.658285	0.350576	91	6.58E-05	3.51E-05
92	0.445553	0.416849	92	4.46E-05	4.17E-05
93	0.194001	0.436939	93	1.94E-05	4.37E-05
94	0.71163	0.23139	94	7.12E-05	2.31E-05
95	1.334134	0.22719	95	0.000133	2.27E-05
96	1.141999	0.667408	96	0.000114	6.67E-05
97	1.499425	1.143458	97	0.00015	0.000114
98	1.492899	2.239307	98	0.000149	0.000224
99	1.113193	1.132913	99	0.000111	0.000113

VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.767946
R Square	0.589741
Adjusted R	0.538458
Standard E:	0.310974
Observation	10

ANOVA

	df	SS	MS	F	ignificance F
Regression	1	1.11209	1.11209	11.49986	0.009484
Residual	8	0.773637	0.096705		
Total	9	1.885726			

	Coefficients	standard Err.	t Stat	P-value
Intercept	-10.0522	3.236897	-3.10549	0.014544
Fiscal Year	0.116103	0.034237	3.391144	0.009484

NON-VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.767604
R Square	0.589216
Adjusted R	0.537868
Standard E:	0.45075
Observation	10

ANOVA

	df	SS	MS	F	ignificance F
Regression	1	2.331437	2.331437	11.47496	0.009536
Residual	8	1.625408	0.203176		
Total	9	3.956845			

	Coefficients	standard Err.	t Stat	P-value
Intercept	-15.2015	4.691822	-3.23999	0.011878
Fiscal Year	0.168107	0.049626	3.387471	0.009536

Figure D-13. HFACS-ME Part Failure Regression Output

HF-ME Part Failure Regression C-130

Fiscal Year	FISCAL YEAR			
	VR	Non-VR	VR	OTHER
90	0	0	90	0
91	0	0.372849127	91	0 3.7285E-05
92	0	0.443764006	92	0 4.4376E-05
93	0	0.46868043	93	0 4.6868E-05
94	0.97905	0.247334966	94	9.79048E-05 2.4733E-05
95	1.51527	0.243854858	95	0.000151527 2.4385E-05
96	2.21125	0.721934785	96	0.000221125 7.2193E-05
97	1.43978	1.239310943	97	0.000143978 0.00012393
98	2.91418	2.369668246	98	0.000291418 0.00023697
99	1.35842	1.210331389	99	0.000135842 0.00012103

VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.40508
R Square	0.16409
Adjusted R Squa	-0.0449
Standard Error	0.71787
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.404642144	0.40464214	0.78520509	0.425614195
Residual	4	2.061332244	0.51533306		
Total	5	2.465974388			

	Coefficient	Standard Error	t Stat	P-value
Intercept	-12.938	16.56228651	-0.7811433	0.47836491
Fiscal Year	0.15206	0.17160304	0.88611799	0.42561419

NON-VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.78326
R Square	0.6135
Adjusted R Squa	0.51688
Standard Error	0.55544
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	1	1.958848278	1.95884828	6.34929646	0.065372021
Residual	4	1.234056901	0.30851423		
Total	5	3.19290518			

	Coefficient	Standard Error	t Stat	P-value
Intercept	-31.28	12.81486063	-2.4409303	0.07113703
Fiscal Year	0.33457	0.132775692	2.51978103	0.06537202

Figure D-14. HFACS-ME Part Failure C-130 Regression Output

HF-ME Part Failure Regression C-9

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0.62274256	0	90	6.22743E-05	0
91	0.68155485	0	91	6.81555E-05	0
92	0.49349816	0	92	4.93498E-05	0
93	0.22740193	0	93	2.27402E-05	0
94	0.6863418	0	94	6.86342E-05	0
95	1.44175317	0	95	0.000144175	0
96	0.97012029	0	96	9.7012E-05	0
97	1.82496024	0	97	0.000182496	0
98	1.20718274	0	98	0.000120718	0
99	0.8777833	0	99	8.77783E-05	0

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.60235432
R Square	0.36283072
Adjusted R Squa	0.28318457
Standard Error	0.4027478
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.73893386	0.73893386	4.55553322	0.065346864
Residual	8	1.297646313	0.16220579		
Total	9	2.036580173			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-8.0401683	4.192166498	-1.9179029	0.09141069
Fiscal Year	0.09464023	0.044341073	2.13436951	0.06534686

Figure D-15. HFACS-ME Part Failure C-9 Regression Output

Squadron HF-ME Regression

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0.60443656	0.480430466	90	6.04437E-05	4.8043E-05
91	1.75542536	1.051727462	91	0.000175543	0.00010517
92	0.44555338	0.625273557	92	4.45553E-05	6.2527E-05
93	0.19400147	1.31081642	93	1.94001E-05	0.00013108
94	0.17790745	0.46278085	94	1.77907E-05	4.6278E-05
95	0.83383363	0.227190113	95	8.33834E-05	2.2719E-05
96	0.9788567	0	96	9.78857E-05	0
97	1.16621962	0.91476662	97	0.000116622	9.1477E-05
98	1.4928994	1.741683461	98	0.00014929	0.00017417
99	0.7421288	1.1329134	99	7.42129E-05	0.00011329

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.21085221
R Square	0.04445865
Adjusted R Squa	-0.074984
Standard Error	0.54275905
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.109650584	0.10965058	0.37221751	0.558725661
Residual	8	2.35669912	0.29458739		
Total	9	2.466349704			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-2.606041	5.649531367	-0.4612845	0.65687707
Fiscal Year	0.0364568	0.059755805	0.61009631	0.55872566

NON-VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.27518008
R Square	0.07572408
Adjusted R Squa	-0.0398104
Standard Error	0.54270573
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.193041706	0.19304171	0.655424	0.441592486
Residual	8	2.356236053	0.29452951		
Total	9	2.549277759			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-3.7764437	5.648976303	-0.6685182	0.52262043
Fiscal Year	0.04837251	0.059749934	0.80958261	0.44159249

Figure D-16. Squadron Related HFACS-ME Regression Output

Squadron HF-ME Regression C-130

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0	0.509156328	90	0	5.0916E-05
91	0	1.11854738	91	0	0.00011185
92	0	0.665646009	92	0	6.6565E-05
93	0	1.406041291	93	0	0.0001406
94	0.97904836	0.494669931	94	9.79048E-05	4.9467E-05
95	1.51526631	0.243854858	95	0.000151527	2.4385E-05
96	1.47416525	0	96	0.000147417	0
97	0.71989058	0.991448754	97	7.19891E-05	9.9145E-05
98	2.91417747	1.843075303	98	0.000291418	0.00018431
99	0.6792094	1.210331389	99	6.79209E-05	0.00012103

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.12471345
R Square	0.01555345
Adjusted R Squa	-0.2305582
Standard Error	0.92392254
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.053946785	0.05394679	0.06319671	0.813899684
Residual	4	3.414531418	0.85363285		
Total	5	3.468478203			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-3.9775635	21.31630136	-0.1865973	0.86105802
Fiscal Year	0.05552183	0.22085973	0.25138955	0.81389968

NON-VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.7326223
R Square	0.53673544
Adjusted R Squa	0.4209193
Standard Error	0.52008612
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	1	1.253550119	1.25355012	4.63437508	0.097678723
Residual	4	1.081958277	0.27048957		
Total	5	2.335508396			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-25.030078	11.99917954	-2.0859824	0.10530791
Fiscal Year	0.2676405	0.124324361	2.15275987	0.09767872

Figure D-17. Squadron Related HFACS-ME C-130 Regression Output

Fiscal Year	FISCAL YEAR			
	VR	Non-VR	VR	OTHER
90	0.62274256	0	90	6.22743E-05
91	1.81747961	0	91	0.000181748
92	0.49349816	0	92	4.93498E-05
93	0.22740193	0	93	2.27402E-05
94	0	0	94	0
95	0.72087659	0	95	7.20877E-05
96	0.97012029	0	96	9.7012E-05
97	1.56425164	0	97	0.000156425
98	0.90538705	0	98	9.05387E-05
99	0.8777833	0	99	8.77783E-05

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.13959128
R Square	0.01948573
Adjusted R Squa	-0.1030786
Standard Error	0.58171671
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.05379919	0.05379919	0.15898372	0.700524912
Residual	8	2.70715469	0.33839434		
Total	9	2.76095388			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-1.5932425	6.055038248	-0.2631267	0.79910286
Fiscal Year	0.02553647	0.064044902	0.39872763	0.70052491

Figure D-18. Squadron Related HFACS-ME C-9 Regression Output

Non-Squadron HF-ME Regression

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0.60443656	0.160143489	90	6.04437E-05	1.6014E-05
91	0.87771268	0.350575821	91	8.77713E-05	3.5058E-05
92	0.22277669	0.208424519	92	2.22777E-05	2.0842E-05
93	0.19400147	1.092347017	93	1.94001E-05	0.00010923
94	0.53372236	0.694171275	94	5.33722E-05	6.9417E-05
95	0.66706691	0	95	6.67067E-05	0
96	1.30514226	1.112347052	96	0.000130514	0.00011123
97	1.33282242	2.515608205	97	0.000133282	0.00025156
98	0.7464497	2.488119231	98	7.4645E-05	0.00024881
99	1.66978979	0.90633072	99	0.000166979	9.0633E-05

VR REGRESSION

SUMMARY OUTPUT

Regression Statistics

Multiple R	0.66719704
R Square	0.44515189
Adjusted R Squa	0.37579588
Standard Error	0.38429859
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.947898184	0.94789818	6.4183604	0.035066647
Residual	8	1.181483275	0.14768541		
Total	9	2.129381459			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-9.3140536	4.00013035	-2.3284375	0.04827931
Fiscal Year	0.1071899	0.042309883	2.53344832	0.03506665

NON-VR REGRESSION

SUMMARY OUTPUT

Regression Statistics

Multiple R	0.660797
R Square	0.43665268
Adjusted R Squa	0.36623426
Standard Error	0.72023185
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	3.216581188	3.21658119	6.20083076	0.037513653
Residual	8	4.149871286	0.51873391		
Total	9	7.366452473			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-17.706783	7.496830087	-2.3619027	0.04582193
Fiscal Year	0.19745598	0.079294916	2.49014673	0.03751365

Figure D-19. Non-Squadron Related HFACS-ME Regression Output

Non-Squadron HF-ME Regression C-130

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0	0.169718776	90	0	1.6972E-05
91	0	0.372849127	91	0	3.7285E-05
92	0	0.221882003	92	0	2.2188E-05
93	0	0.93736086	93	0	9.3736E-05
94	0	0.742004897	94	0	7.42E-05
95	0	0	95	0	0
96	2.94833051	1.203224642	96	0.000294833	0.00012032
97	2.15967173	1.982897509	97	0.000215967	0.00019829
98	2.18563311	2.632964718	98	0.000218563	0.0002633
99	3.396047	0.968265111	99	0.000339605	9.6827E-05

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.29194387
R Square	0.08523122
Adjusted R Squa	-0.3721532
Standard Error	0.7091938
Observations	4

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.093723227	0.09372323	0.18634484	0.708056133
Residual	2	1.005911688	0.50295584		
Total	3	1.099634915			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-10.67641	30.92524111	-0.3452329	0.76284753
Fiscal Year	0.13691109	0.317161109	0.43167678	0.70805613

NON-VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.00931112
R Square	8.6697E-05
Adjusted R Squa	-0.49987
Standard Error	0.93072167
Observations	4

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.000150214	0.00015021	0.00017341	0.990688876
Residual	2	1.732485663	0.86624283		
Total	3	1.732635877			

	Coefficients	Standard Error	t Stat	P-value
Intercept	2.23124899	40.58522815	0.05497687	0.96115482
Fiscal Year	-0.0054811	0.416231385	-0.0131685	0.99068888

Figure D-20. Non-Squadron Related HFACS-ME C-130 Regression Output

Non-Squadron HF-ME Regression C-9

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0.62274256	0	90	6.22743E-05	0
91	0.90873981	0	91	9.0874E-05	0
92	0.24674908	0	92	2.46749E-05	0
93	0.22740193	3.264773098	93	2.27402E-05	0.0003265
94	0.6863418	0	94	6.86342E-05	0
95	0.96116878	0	95	9.61169E-05	0
96	0.72759022	0	96	7.2759E-05	0
97	0.78212582	0	97	7.82126E-05	0
98	0.30179568	0	98	3.01796E-05	0
99	0.8777833	0	99	8.77783E-05	0

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.16428793
R Square	0.02699052
Adjusted R Squa	-0.0946357
Standard Error	0.29202698
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.018924751	0.01892475	0.22191375	0.650163937
Residual	8	0.682238076	0.08527976		
Total	9	0.701162828			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.7970207	3.039683259	-0.2622052	0.79978858
Fiscal Year	0.01514566	0.032151113	0.47107722	0.65016394

Figure D-21. Non-Squadron Related HFACS-ME C-9 Regression Output

Non-Squadron HF-ME Regression C-20

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0	0	90	0	0
91	0	0	91	0	0
92	0	0	92	0	0
93	0	0	93	0	0
94	0	0	94	0	0
95	0	0	95	0	0
96	1.53917193	0	96	0.000153917	0
97	2.57234727	25.12562814	97	0.000257235	0.0025126
98	0	0	98	0	0
99	2.00040008	10000	99	0.00020004	#DIV/0!

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.13914663
R Square	0.01936179
Adjusted R Squa	-0.4709573
Standard Error	1.3375511
Observations	4

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.070645963	0.07064596	0.03948813	0.860853368
Residual	2	3.578085897	1.78904295		
Total	3	3.64873186			

Figure D-22. Non-Squadron Related HFACS-ME C-20 Regression Output

Squadron HF-ME Part Failure Regression

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0.402958	0	90	4.03E-05	0
91	0.658285	0.175288	91	6.58E-05	1.75E-05
92	0.222777	0.416849	92	2.23E-05	4.17E-05
93	0.194001	0.436939	93	1.94E-05	4.37E-05
94	0.177907	0.23139	94	1.78E-05	2.31E-05
95	0.833834	0.22719	95	8.34E-05	2.27E-05
96	0.652571	0	96	6.53E-05	0
97	0.999617	0.686075	97	1E-04	6.86E-05
98	1.306287	1.492872	98	0.000131	0.000149
99	0.185532	0.906331	99	1.86E-05	9.06E-05

VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.394961
R Square	0.155994
Adjusted R	0.050494
Standard Err	0.384575
Observation	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.218683	0.218683	1.47861	0.258652
Residual	8	1.183182	0.147898		
Total	9	1.401865			

	Coefficient	Standard Err	t Stat	P-value
Intercept	-4.30195	4.003005	-1.07468	0.313859
Fiscal Year	0.051485	0.04234	1.215981	0.258652

NON-VR REGRESSION

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.689876
R Square	0.475929
Adjusted R	0.41042
Standard Err	0.355559
Observation	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.918633	0.918633	7.265114	0.027268
Residual	8	1.011556	0.126444		
Total	9	1.930189			

	Coefficient	Standard Err	t Stat	P-value
Intercept	-9.51456	3.701308	-2.57059	0.033097
Fiscal Year	0.105522	0.039149	2.695388	0.027268

Figure D-23. Squadron Related HFACS-ME Part Failure Regression Output

Non-Squadron HF-ME Part Failure Regression

Fiscal Year	VR	Non-VR	FISCAL YEAR		
			VR	OTHER	
90	0	0	90	0	0
91	0	0.175288	91	0	1.7529E-05
92	0.222777	0.208425	92	2.2278E-05	2.0842E-05
93	0.194001	0.436939	93	1.94E-05	4.3694E-05
94	0.533722	0.23139	94	5.3372E-05	2.3139E-05
95	0.667067	0	95	6.6707E-05	0
96	0.652571	0.667408	96	6.5257E-05	6.6741E-05
97	0.833014	0.686075	97	8.3301E-05	6.8607E-05
98	0.373225	1.492872	98	3.7322E-05	0.00014929
99	0.927661	0.226583	99	9.2766E-05	2.2658E-05

VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.85566
R Square	0.732154
Adjusted R	0.698674
Standard E	0.182717
Observatio	10

ANOVA

	df	SS	MS	F	Significance F
Regressior	1	0.730076	0.730076	21.86795	0.00158944
Residual	8	0.267085	0.033386		
Total	9	0.997162			

	Coefficient	standard Err.	t Stat	P-value
Intercept	-8.44933	1.90189	-4.4426	0.00216
Fiscal Yea	0.094071	0.020117	4.676318	0.001589

NON-VR REGRESSION

SUMMARY OUTPUT

<u>Regression Statistics</u>	
Multiple R	0.576851
R Square	0.332757
Adjusted R	0.249352
Standard E	0.388886
Observatio	10

ANOVA

	df	SS	MS	F	Significance F
Regressior	1	0.603361	0.603361	3.989638	0.08084021
Residual	8	1.209856	0.151232		
Total	9	1.813216			

	Coefficient	standard Err.	t Stat	P-value
Intercept	-7.66903	4.047875	-1.89458	0.094755
Fiscal Yea	0.085519	0.042815	1.997408	0.08084

Figure D-24. Non-Squadron Related HFACS-ME Part Failure Regression Output

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